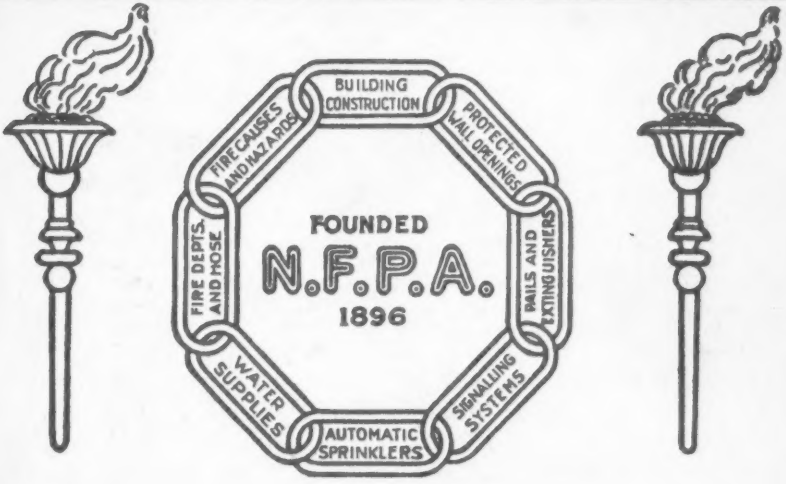
Vol. 36 JULY, 1942 No. 1
Published in two sections—Part 1

QUARTERLY
OF THE

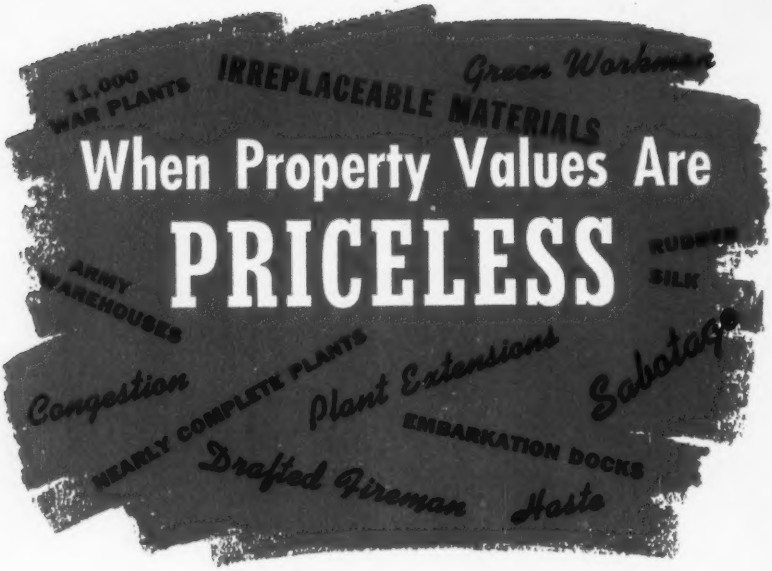
NATIONAL FIRE PROTECTION ASSOCIATION



"To Promote the Science and Improve the Methods of Fire Protection and Prevention."

PUBLISHED QUARTERLY AT BOSTON, MASS., BY THE
NATIONAL FIRE PROTECTION ASSOCIATION

Printed in U. S. A.



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Vol. 36 July, 1942 No. 1

QUARTERLY

OF THE

National Fire Protection Association

Subscriptions to the QUARTERLY are accepted only as a part of the general publications of the Association which are sent to members. Associate membership is open to anyone interested; annual dues $10.

Entered as second-class matter December 15, 1928, at the Post Office at Boston, Mass., under act of March 3, 1879.

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60 BATTERYMARCH STREET, BOSTON, MASS.

National Fire Protection Association

INTERNATIONAL

A NON-PROFIT TECHNICAL AND EDUCATIONAL ORGANIZATION

To promote the science and improve the methods of fire protection and prevention.

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West Virginia Fire Underwriters' Association.
West Virginia Inspection Bureau.

More than six thousand Associate Members

Executive Office, 60 Batterymarch Street, Boston, Mass., U. S. A.

Printed in U. S. A.

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Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

Fire continues to sabotage war production. This factory was not itself working on war orders, but the fire spread to a foundry working on castings for shells and airplane parts. Wooden interior construction. No automatic sprinklers.

The Quarterly

Vol. 36 July, 1942 No. 1

Meetings of Board of Directors.

Atlantic City, May 11, 1942.

Present.

Albert T. Bell, Chairman
Alvah Small, President
D. J. Price, Vice-President
Richard E. Vernor, Vice-President.
George W. Elliott, Past President
Hovey T. Freeman, Secretary-Treasurer
Percy Bugbee, General Manager

A. L. Brown	C. W. Pierce
Frank Epps	W. J. Scott
Russell Grinnell	Leon Watson
C. C. Johnson	W. C. Wagner
C. W. Johnson	Lloyd T. Wheeler
H. L. Miner	J. L. Wilds

Business Transacted.

1. The report of the Chairman to the annual meeting was approved.
2. The report of the Treasurer to the annual meeting was approved.
3. A special committee of the Board, consisting of Messrs. Watson, Pierce and Freeman, was appointed to draft a resolution on adequate fire protection of essential commodities in war time to be presented at the first session.
4. A communication from H. S. Bennion, Vice-President and Managing Director of the Edison Electric Institute, to President Small with respect to the Type S fuse situation was discussed and it was agreed that this matter should continue to be handled by the Electrical Committee.
5. The matter of the use of various devices and materials for extinguishing incendiary bombs was discussed and the Executive Office was asked to prepare a statement on the subject.

6. It was voted to record N.F.P.A. approval of revised Standard Methods of Fire Tests of Building Construction and Materials, and new Standard Methods of Fire Tests of Door Assemblies (A.S.T.M. Designations C152-41 and C19-41), for which the N.F.P.A. as a member of the Fire Protection Group under the procedure of the American Standards Association is joint sponsor with the American Society of Testing Materials, the National Bureau of Standards, and the other members of the Fire Protection Group (Associated Factory Mutual Fire Insurance Companies, National Board of Fire Underwriters, Underwriters' Laboratories, Inc.).

7. President Small reported the request of Member Sember from Jacksonville, Fla., that the members select the place of the annual meeting rather than the Board of Directors and that a separate section for city fire marshals be created. It was voted to refer these items for attention of the June Board meeting.

8. It was voted to hold the next meeting of the Board at the Hotel Statler in Boston on June 29.

Boston, June 29, 1942.

Present.

Albert T. Bell, Chairman
Richard E. Vernor, Vice-President
C. C. Johnson, Vice-President
Alvah Small, Past President
S. D. McComb, Past President
Hovey T. Freeman, Secretary-Treasurer

A. L. Brown	W. E. Mallalieu
H. T. Cartlidge	H. L. Miner
George W. Elliott	C. W. Pierce
Russell Grinnell	E. O. Shreve
C. C. Hannah	W. C. Wagner
W. F. Hickey	John L. Wilds

Percy Bugbee, General Manager, Robert S. Moulton, Technical Secretary, Horatio Bond, Chief Engineer.

Guest: H. O. Lacount, Past President.

Present during part of the meeting: Messrs. H. T. Bussmann, representing the McGraw Electric Company, and E. A. Brand, J. C. Langdell and Alexander Maxwell, representing the Edison Electric Institute.

Business Transacted.

1. General Manager Bugbee reported a visit to Dr. David J. Price who had been ill since the annual meeting. The Board voted to express their sincere regret that Dr. Price was unable to be present and to extend to him their best wishes for a speedy recovery.

2. General Manager Bugbee read letters from several past presidents who had been invited to attend the meeting as guests.

3. In accordance with the recommendation of the annual meeting, the following officers of the Corporation were elected for the year 1942-1943: President, David J. Price; Vice-President, Richard E. Vernor; Vice-President, C. C. Johnson; Secretary-Treasurer, Hovey T. Freeman; Chairman Board of Directors, Albert T. Bell.

4. The Advisory Committee for 1942-1943 was appointed as follows: Albert T. Bell, Chairman; David J. Price; Richard E. Vernor; C. C. Johnson; Hovey T. Freeman, C. W. Pierce.

5. Messrs. A. L. Brown and Lloyd T. Wheeler were selected to complete the Nominating Committee for 1943.

6. It was voted to hold the 47th annual meeting in Chicago the week of May 17, 1943, with authority to the Advisory Committee to make any change that might be indicated by war emergency conditions.

7. A request from Member H. Sember of Jacksonville, Florida, that members be given an opportunity in the annual meeting to decide the place of the next annual meeting was considered without action. The discussion indicated the view that such a policy would be likely to result in the selection of the meeting place on the basis of political considerations and would not be to the best interests of the Association. The discussion further indicated that under present procedure all members who wish to register their views relative to the selection of meeting places have opportunity to file communications on this subject for consideration of the Board of Directors.

8. The Program Committee for the 1943 annual meeting was appointed as follows: the President, Chairman of the Board of Directors and the General Manager. Suggestions relative to the 1943 program were referred to the Program Committee.

9. The budget for 1942-43 as recommended by the Finance Committee was approved.

10. It was voted to express the appreciation of the Board to the members of the staff of the Association for their competent and conscientious services.

11. A resolution submitted by Member Powell Evans to the 1942 annual meeting and referred by the meeting to the Board was considered without action.

12. A proposal for the creation of a separate section for city fire marshals made by certain of the city fire marshals now members of the N.F.P.A. Fire Marshals Section was considered without action on the ground that the city fire marshals now have sufficient facilities for meetings, discussion and interchange of information within the framework of the present Fire Marshals Section and there has been no evidence submitted to the Board that the proposed

separate section would be of sufficient advantage either to the city fire marshals or to the Association to justify the proposed action.

13. Members of the staff present reported on N.F.P.A. war activities, the response from government officials to the resolution on fire protection for war properties adopted at the 1942 annual meeting, conferences with various government agencies, and other activities of the N.F.P.A. staff and N.F.P.A. members contributing to the war effort.

14. After discussion of fire hazard conditions and fire protection problems that might be anticipated after the termination of the war emergency, the staff was instructed to consider the desirability of the creation of a committee on Post War Planning and report thereon to the Board at the January meeting.

Technical Committee Matters.

15. In accordance with the action of the annual meeting in referring reports to technical committees for submission to the Board with power, the following action was taken on recommendation of the technical committees concerned:

Dust Explosion Hazards.

A revised text of the Code for Explosion and Fire Protection in Plants Producing or Handling Magnesium Powder or Dust (Advance Reports, 1942, page 21) was tentatively adopted, including rearrangement and revisions of the preprinted text and the addition of a second section on Collection and Disposal of Dust from Grinding, Buffing and Similar Dust-Producing Operations in the Handling of Magnesium Alloy Castings. (The revised text will appear in a separately printed edition of this tentative standard.)

Authority was given for submission to the Board by letter ballot of a pending revision of the Standards on the Installation of Pulverized Fuel Systems upon its completion by the committee.

Field Practice.

The title of the Standard on Smoke Pipes and Stove Pipes (Advance Reports, 1942, page 34) was amended by deleting the words "the Installation of" so that the title will read: "Recommended Good Practice for Smoke Pipes and Stove Pipes." The Standard was further amended by adding at the end of the first paragraph the following:

> "They are not intended to cover clearances between pipes and combustible materials, or protection of exposed woodwork from the heat of the pipe; such features are covered by building codes and by the installation standards for various types of heating and cooking equipment."

Hazardous Chemicals and Explosives.

Amendments to the Table of Common Hazardous Chemicals, Edition of 1941, were adopted. (These amendments will appear in the 1942 edition of the Table.)

16. The report of the Committee on Technical Committee Procedure was adopted, including action on the following items:

The establishment by the Electrical Committee of a special procedure for expediting action on war emergency amendments of the National Electrical Code was approved as involving no sacrifice in the integrity of the Association's standards since all interim amendments will be subject to eventual review and official action in the regular manner.

The policy of facilitating similar procedure for emergency amendments by other committees as occasion may require was approved and the Executive Office was requested to

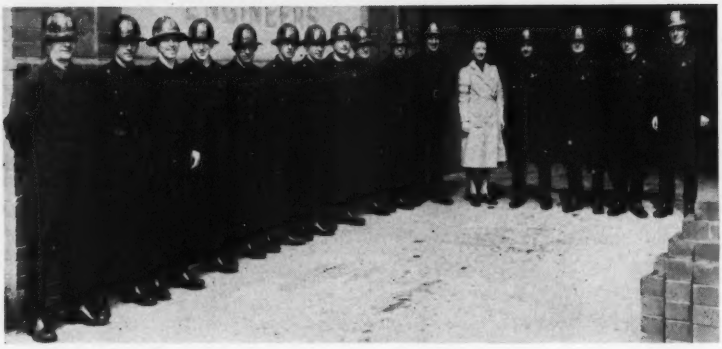
call the attention of the various technical committees to this action. It was reported that other committees have not as yet had occasion to institute similar emergency procedure as in most cases the size and organization of the committees are such that action can be taken through regular procedure without undue delays.

The Committee on Technical Committee Procedure was authorized to add to the personnel of the Manufacturing Hazards Council members to facilitate the consideration of new industrial fire hazards (the membership of the Council has been limited to the chairmen of certain committees ex-officio).

A request from the Firetox System, Inc., for the development of installation standards for their device was considered. No action was taken on the ground that at the present time there has not been sufficient development of carbon tetrachloride extinguishing systems, as distinguished from individual extinguishing devices, to justify any general installation standards and that the installation features of the Firetox device are sufficiently covered in the reports thereon published by Underwriters' Laboratories, Inc., and by the Factory Mutual Laboratories.

17. A list of technical committee appointments recommended by the Committee on Technical Committee Procedure was approved and the committee was authorized to make additional appointments to technical committees prior to the printing of the 1942 Year Book, subject to confirmation by the Board at its next meeting. (The revised committee lists will appear in the 1942 Year Book.)

18. A communication from Mr. H. S. Bennion, Vice-President and General Manager of the Edison Electric Institute, relative to the requirement for the use of Type S fuses appearing in Par. 2452 of the National Electrical Code, edition of 1940, was considered. The subject was discussed by Messrs. Alexander Maxwell, E. A. Brand and J. C. Langdell, representing the Edison Electric Institute, and by Mr. H. T. Bussmann, representing the McGraw Electric Company, fuse manufacturers, who had been invited to appear before the meeting. After discussion it was voted that it was the sense of the meeting that the November 1, 1941, effective date of Par. 2452 of the National Electrical Code, edition of 1940, be postponed for the duration of the war emergency, and that the Emergency Committee of the Electrical Committee be requested to put this postponement into effect in accordance with established procedure.



Australian Sprinkler Brigade.

A unique phase of Australian Civilian Defense is the Fire Brigade Sprinkler Reserve whose job it is to take care of sprinkler installations during and after an air raid so that the Fire Department can concentrate on fire fighting. A group of auxiliary firemen and four units of this service are shown in the accompanying photographs contributed by T. M. Marriott, N.F.P.A. member from Melbourne, Australia, who, members may recall, spoke on "Automatic Sprinkler Protection in Australia" at the 1938 annual meeting at Atlantic City. Mr. Marriott informs us that auxiliary sprinkler brigades have been formed in all the capital cities of Australia by Automatic Fire Sprinklers Pty., Ltd., in conjunction with Wormald Bros. This auxiliary fire service is composed of members of the office, engineering and sprinkler staffs of each of the two companies. Each member of the service has been attested as an Auxiliary Fireman and must regularly attend drills at night or on Saturdays and Sundays.

Fire Protection in the Airplane Industry.

By Winthrop M. Jones, Chief Engineer,
Factory Insurance Association, Hartford, Conn.

This industry, in its transition within just a few years from the production of custom-built to mass-produced all metal ships, has been undergoing much the same process that the automotive industry did for twenty years or more. Indeed these growing pains still continue. As to fire protection, it has borrowed from and profited by the lessons learned in that industry during those years when the strife was economic and time permitted theories to be tested—until the point has been reached where it is large enough and of such importance as to warrant treatment in a class by itself.

Even with the advantages of similarity in processes and with such stores of accumulated wisdom to draw upon, there are marked differences which make fire protection engineering for these plants a real problem.

Among these differences are:

Extreme bulk and value of the product.

Excessive building heights and tremendous unbroken areas, greatly influencing automatic sprinkler protection.

Haste required by our national emergency in planning, building and equipping.

Continuing changes in design and materials often necessitating complete re-arrangement of processes and production lines.

Need of including with fire and explosion hazards the far-reaching hazards of sabotage.

General Arrangement, Construction and Areas.

The general layout of a plant is influenced by a number of factors which make it difficult to formulate a set of rules for guidance. For example, the position and shape of the property with respect to its flying field, particularly the major runways, are all important. Prevailing wind direction is important, particularly in northern locations, since outlet doors at the end of the assembly line should be at the leeward side to avoid excessive drafts when open. The same consideration applies to the hangar. The position of railroad lines and possible sidings has a great bearing; so also do highways. The probable future expansion program is of course always important.

Disregarding for the moment the future monsters of the air, present-day ships run up to three or four hundred thousand dollars in value; sizes all the

This article was presented by Mr. Jones as a paper at the 1942 Annual Meeting of the National Fire Protection Association, Atlantic City, May 11-14, in the session on war industry fire protection. The article is a condensation of the more complete publication on this subject being issued by the Factory Insurance Association, Hartford, Conn.

Factory Insurance Association, with permission of the manufacturer.

General character of the final assembly and fitting-out area in a typical modern plant.

way up to 200 ft. wing spread. Buildings under one roof and sometimes without cut-offs have approached areas of 2,000,000 sq. ft. or more, representing value concentrations of tens of millions, subject to one fire. The tendency has been for even larger main units. From the single standpoint of conservation of our national resources this is a mistake, for obviously, the larger a single unit is, the greater are the chances of catastrophe.

Experience indicates that an area of 350,000 sq. ft. would be a reasonable limit for the main manufacturing or assembly building, although the type of construction and degree of fire protection afforded, as well as the amount of combustible material within the building, have a bearing on this limit. Certainly 500,000 sq. ft. would be a high limit even with non-combustible construction, and when this area is exceeded, reasonable security against disaster has been sacrificed. Even with such area limits, the value of buildings and contents, under present-day conditions, will run up to $20,000,000 or more.

If the main building must be of combustible construction, then the suggested area limit should be further reduced, for under these conditions a possible sprinkler failure, such as might occur with bombing or a ship crash on the roof, could result in total destruction.

The plant designer should start out, therefore, with the necessity of limiting unit areas subject to one fire to reasonable figures, and of confining con-

struction to the heavy non-combustible classes, at least for main buildings.

The greater the distance of course between buildings the less the chances of communication of fire from one to another under adverse conditions such as high wind or rupture of underground mains. Separation should be gauged by the size of buildings involved and by their position with respect to one another—certainly not less than 50 ft. for moderate sized buildings nor less than 100 ft. for extremely large buildings. This refers to heavy non-combustible construction. For combustible construction these minimum limits should be doubled.

The provision of fire cut-offs in the major buildings, for further subdivision, is difficult and sometimes impossible due chiefly to the size of openings required in any proposed fire wall and because of interference by overhead trolley or carrier systems for the movement of stock or sub-assemblies. However, with careful planning from the start, satisfactory cut-offs may be provided for high value areas such as those housing engines and propellers, instruments or stores; auxiliary processes, such as die making, heat treating, machine shop, shipping; and if possible complete separation of final assembly lines from manufacturing.

Detached buildings for paint and oil storage and preferably paint mixing should by all means be provided. Hangars should be detached and in fact usually are, probably because it is both more economical and practical to provide light exterior walls and detachment than to attempt the erection of standard masonry division walls of tremendous area.

Cut-off areas for small parts paint finishing, dipping, doping, and complete ship or camouflage painting should be the hard and fast rule. Details covering these and other special hazard protection will be described later.

Whether the product is a bomber, pursuit plane, fighter or trainer, whether the plant is merely for assembly or manufacturing and assembly, building heights will be from 25 ft. to 45 ft. in the clear. Allowing for truss depth requirements, roof pitch, overhead trolleys, etc., final heights from floor to roof deck will reach a fair average of 50 ft. This contrasts with 25 ft. for the modern one-story automotive plant.

Now, there is a marked difference of efficiency between the action of automatic sprinklers on a fire 25 ft. below them and on a fire 50 ft. below. Much more water is required at 50 ft. because of delayed action of the fusible elements and the resulting larger number of heads that would operate on a given fire.

Offices, garages, model shops, boiler houses and other auxiliary buildings should preferably be detached; but if adjoining, must be cut off, and protection provided to suit the individual class.

Boiler houses, even of fire-resistive construction in which liquid fuel is used, should be sprinklered, at least the roof area over the firing aisle.

The Austin Company, Engineers and Builders.

A view of fuselage and final assembly area, showing relative building height, nature of fixtures and individual metal working platforms.

With finished ships coming off the assembly lines at a high rate, exceedingly large and high flight hangars are required to accommodate them both before and after ground or flight testing or until delivery. Absence of columns with the usual spans required will call for deep truss or arch construction. In any event much wasted volume is encountered, with roof deck heights sometimes as much as 170% of ship height.

This feature of hangar ceiling heights is, as with manufacturing buildings, of the utmost importance. Indeed it is a governing factor in fire protection design as I will endeavor to show later on.

Present-day hangar areas may run up to 100,000 sq. ft. or more. Considering the tremendous value of ships in such an area, the importance of scheduled delivery in this emergency period, the need of conserving the nation's resources, coupled with the fact that even the best automatic sprinkler system is handicapped in protecting contents of high buildings, our effort should be to limit hangar areas (hence values) to approximately 50,000 sq. ft. Even so, it is entirely possible for contents value in such an area to reach $2,000,000 or more. As with main manufacturing buildings, non-combustible construction is recommended for all hangars.

The clamor for building materials by all industries at the same time has resulted in a shortage of certain materials of the fire-resistive class. This short-

The Austin Company, Engineers and Builders.

Ships "Ready to Go" in the output end of the assembly building of a typical plant.

age, aggravated by the demand for building schedules to be maintained, has resulted in some ingenious combinations of wall and roof deck materials. The blackout requirement, introducing, as it does, new and far-reaching problems of air conditioning, lighting and acoustics, has had its effect on the type of construction to be chosen.

In general, masonry walls should be used wherever possible for exterior walls—always for divisional walls. Masonry has given way to some extent to lighter forms of wall construction, all of which must be placed in the non-combustible class. From a fire protection standpoint, this type of exterior wall construction may be considered generally satisfactory for the occupancy involved, but only if protected with automatic sprinklers. Even so, steel supporting columns in special hazard areas and in all division walls should be protected in accordance with the N.F.P.A. and National Board of Fire Underwriters' Standard Building Code.

Heat and sound insulating materials used should be non-combustible and unless of a hard surface nature and not susceptible to water damage, to be surfaced on the interior with a hard non-combustible material. If combustible insulating materials must be resorted to, they should by all means be so treated as to retard fire and in addition surfaced on the interior with metal or hard non-combustible sheathing.

Extensive decking or mezzanine floors should be of concrete and steel to further reduce to a minimum the total amount of combustible material.

Large filters in air conditioning systems should be protected in conformance with Standards for Air Conditioning, Warm Air Heating, Air Cooling and Ventilating Systems.*

Roof covering for major buildings is an important consideration. Covering should rate as Class A or B as defined by the Underwriters' Laboratories. Surfacing with roofing gravel is recommended where the pitch is not too great, to afford added protection against a possible gasoline fire on the roof (as might be caused by a plane crash) and against hail, not to mention the added advantage of weight which lessens the danger of lifting or tearing in high winds.

All portions of roofs should be accessible for fire fighting by providing permanent ladders from yard to roof and between roofs of different levels, at strategic points. Where building widths are more than 500 ft., it is advisable to supplement yard hydrant and hose equipment with auxiliary hydrants or 2½-in. valved hose connections with equipment on the roof at intervals of 350 ft. or less, to more readily take care of a roof fire.

Adequate protection against windstorms requires roof decking to be tied to purlins, purlins to trusses or girders, and the latter to walls and footings in such a manner as to resist a gross lifting force of 30 lbs. per sq. ft.—and 45 lbs. per sq. ft. for monitors, roof structures or overhanging eaves, all in accordance with modern standard practice. So much for general construction, arrangement, etc.

Occupancy.

The processes of a full-fledged manufacturing and assembly plant are many and varied. With present materials of construction and design, the occupancy resembles a combination of machine shop and sheet metal worker, with paint finishing and the handling of gasoline. I will not attempt to go into details of occupancy up to the point where the ship takes shape, because practically all these operations are much the same as we find in the average metal worker, and methods and details of protection therefore are well known to all of us.

Following the ordinary operations of cutting, shaping, and treating the sheet, tube and bar stock, small part making and the like, construction of the sub-assemblies for the ship begins, each usually taking entirely separate paths down through the main building, converging into one or more final assembly lines toward the outlet end. These major parts are fuselage sections, wings or panels, and tail and control surfaces. They are built up usually in heavy rigid fixtures of steel. The work is practically all drilling, riveting and bolting, and but for narrow plank walkways at one or two levels around the fixtures, there is little to burn in the areas, nor is there any great hazard involved except in certain paint departments, details of which will be described later. Each subassembly is fitted up practically complete, often including the paint job, before reaching the final assembly lines.

*N.F.P.A. Standards adopted and published by the National Board of Fire Underwriters.

Fuselages for the very large ships are fabricated in fixed ways of steel, much the same as marine shipways, rather than on movable fixtures. The working decks between ships, often of plank, may be wide and practically solid, thereby obstructing water distribution from the ceiling sprinklers. Additional sprinklers should therefore be placed beneath all such decks if 6 ft. wide or over. Such heads are subject to accidental damage and therefore must be guarded. Side-wall sprinklers may be found useful in these locations. To offset danger of sprinkler leakage the use of supervised heat-actuated systems is recommended.

Wings, too, are very complete, with tubing, control cables, electrical harnesses and fittings—in fact everything but the landing gear and armament —ready for attachment at the final assembly line. They are conveyed by dolly or crane from one station to another. Large panels are fabricated (on edge) in multi-decked fixtures much the same as with large fuselages previously described.

There may be stores of flexible fuel tanks for insertion in the wing compartments of ships of certain types. Such tanks are of combustible material and would contribute fuel to a local fire. There are, too, the landing gear, engine preparation departments, etc., in the sub-assembly areas, where considerable combustible material may be encountered. The fabrication of tail surfaces, ailerons and other small panels may involve some fabric work which with doping presents considerable hazard. The area of fabric in a modern ship's surface, however, is but a very small fraction of the total area—it varies with the type and design of the ship. Doping is merely the impregnating of fabric with nitrated cotton dissolved in a solvent for shrinking and stiffening—also the laminating of fabric sheeting with dope as the cement. It is brush applied—the stock is air dried. Details of protection of this hazard will be covered later.

In the final assembly line wing sections are bolted to the fuselage, engines mounted, cowls, landing gear, tail surfaces, ailerons, etc., attached. Keeping pace with this work is outfitting, which includes the jobs of installing inside trim, radio equipment, armament, instruments, fire extinguishing apparatus, and the hundreds of other items necessary. Except for the final assembly stores, where thousands of parts, instruments and other purchased assemblies are concentrated, there may be little to burn in the area, particularly with the smaller ships; however, the use of many portable electric tools, extension lights, wiring, soldering, greasing, cleaning, brush touching-up, combined with wood staging, step ladders, fabric protective covers often used, creates the need for automatic sprinkler protection.

Paramount among hazards, too, in this area is the possibility that a fueled ship will be returned in some emergency for adjustments or storage.

There should be no question about the need of automatic sprinklers in the final assembly area, for in housing units of such high value in close proximity

to one another, all often subject to near-by manufacturing operations, every known means of fire extinguishment should be adopted. Automatic sprinklers doubtless offer the most economical and practical means. The job of final painting comes in at the completion of assembly and this should be carried on in a special building or room, the protection of which will be described later.

Ground and Flight Testing.

Methods of handling the finished ships with the testing and tuning-up involved vary widely. This is a very important part of the work from a fire protection standpoint, for in this phase is introduced the real fuel hazard.

The completed ship is towed out of the shop on its own landing gear to the filling station and a limited amount of high octane fuel injected into all tanks. A so-called limited amount may be several hundred gallons, however. From here it is towed to a spot on the concrete apron some distance from the building, where it is held in position by blocking the landing wheels or by anchoring with cables to eyelets in the apron. There may be a score or more ships in line undergoing the same tests.

Here the engines are operated while the various tests are made. Danger surrounds this entire phase of operations. Until adjustments and checks are completed fuel lines may not be intact, carburetors may overflow, engines backfire, electrical circuits and auxiliaries misfunction, controls foul, etc., all of which, coupled with the possibilities of static accumulation and collision with other ships or trucks moving about, might well set the stage for a bad fire.

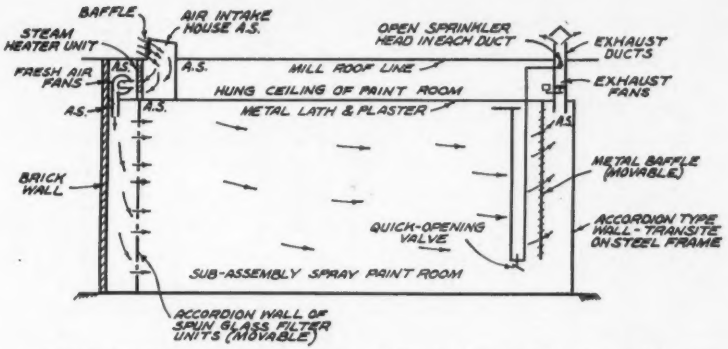
Minor adjustment jobs, such as changing spark plugs, carburetors, oil pumps, etc., are disposed of quickly and the ship is towed to the flight hangar or its apron for flight tests.

Major adjustments, such as correcting leaky or stuck valves, which might involve considerable dismantling, may be done on the apron or in the service hangar or flight hangar. Unfortunately fueling and particularly draining ship tanks takes a great deal of time, and since ground tests must be repeated after major adjustments are completed, the tendency is to leave the fuel in the tanks. If, therefore, the flight hangar cannot accommodate the ship, as is sometimes the case, and there is no service hangar available, there is the possibility that a partially fueled ship will at some time or another be towed into the mill. This is an extremely dangerous thing to do, but it is sometimes done.

Precautions to be taken in connection with ground testing include:

Keeping the apron strictly clean and clear of oil, bolts, nuts, rivets, wire, or other scrap, and of all combustible materials not necessary in conducting the work.

Utilizing anchoring eyelets in the apron rather than blocks to hold ships in place, to prevent damage from sudden gusts of wind.



A typical set-up for spray painting and dipping for small-part or sub-assembly work. Such a room may be used for fuselage or center-section interior painting, augmented by fresh air blowers and tubing.

Grounding all ships (and fueling equipment) during fueling operations, and during the testing.

Permitting no leaky fuel hose, valves or fittings.

Using safety cans or fixed pipe and tank equipment with flexible metallic connections for draining and salvaging fuel.

Limiting the use of portable electrical equipment as much as possible, all such necessary equipment including portable lamps (with power supply system and outlets) to be of a type for Class I Group D locations.

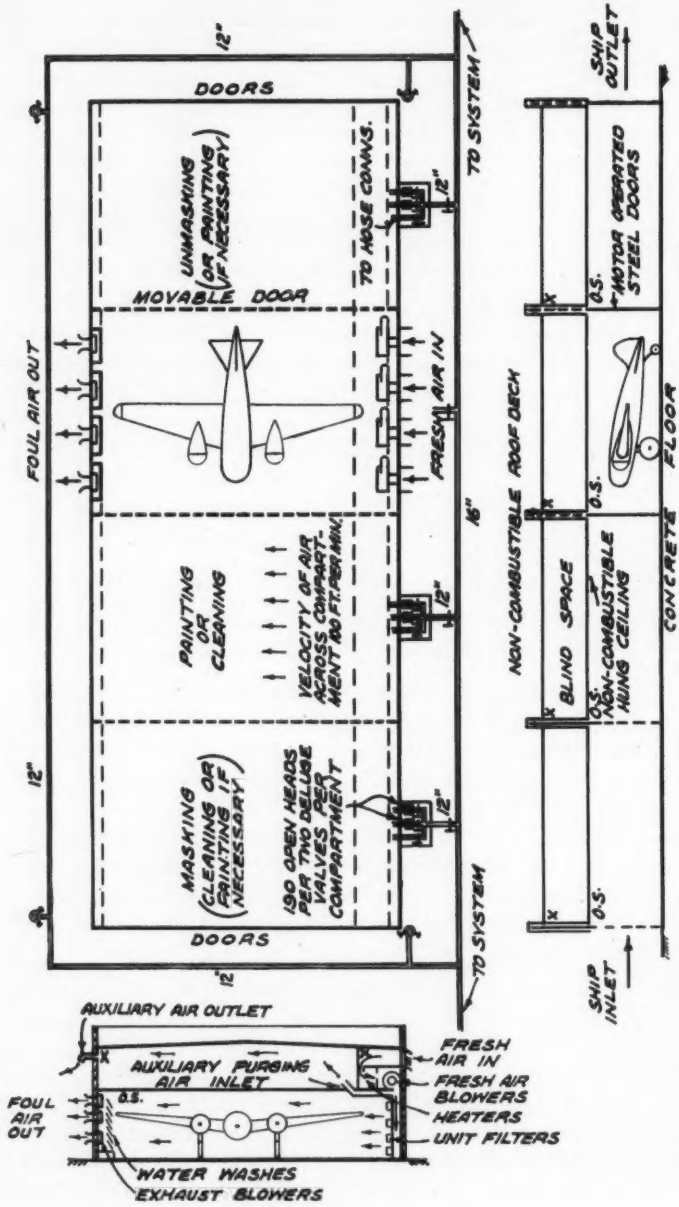
Providing a supply of sand for emergency diking, and asbestos tarpaulins for emergency blanketing.

Providing plenty of first aid equipment in the vicinity, stationing a trained guard with CO_2 or CCl_4 applicators at each ship undergoing fueling, draining, or testing.

A crash truck, with plenty of CO_2 applicators and auxiliaries, is a most desirable piece of apparatus for protection in the area. Extremely large plants or a group of plants well deserve the protection of such well-equipped private fire-fighting units.

In connection with export ships it must be remembered that before disassembly and after ground or flight tests (if such are required) the engine, carburetor, fuel lines and tanks must be purged of tetra-ethyl lead. This is accomplished by draining, fueling and running with straight gasoline. Such operations multiply the chances of a possible flammable liquid fire.

After ground testing, all "fly-away" ships are flight-tested one or more times and otherwise prepared for journey to their destination. This work is carried on at the flight hangar apron, both before and after actual flight. It consists of checking instruments and controls, checking and cleaning oil and fuel



A ship cleaning, masking and camouflaging paint shop, employing movable barriers between ships. The air is purged from one side to the other with water-wash pigment collectors, deluge sprinklered.

strainers, adjusting safety fuel and oil pressures, removing test lines, installing spark plugs, changing oil, adjusting idling mixtures, and many other mechanical operations.

There may be several ships undergoing these operations at the same time, usually placed close together, often close to large open hangar doors, and possibly close to those lined up for ground testing. Obviously the value of finished ships in the area might reach several million dollars, perhaps all more or less subject to one fire. Under unfavorable circumstances a conflagration is quite possible.

The same precautions should be taken for this phase as for ground testing previously outlined. All employees in the testing and hangar areas, right down to the last man, should be taught to fear gasoline and *not* handle it like water. Overcoming in these employees the common failing displayed by the human race of indifference to the danger of gasoline would go a long way toward preventing accidents in this industry.

Special Hazards.

Let us now consider protection of the special hazards, which consist essentially of small parts painting, sub-assembly painting, final or camouflage painting, and hangar hazards. For paint finishing in general, N.B.F.U. and N.F.P.A. standards for "Paint Spraying and Spray Booths" should be followed in detail.

There are many reasons why enclosures around paint departments should be provided, namely:

Operators recognize the fire hazards of paint finishing and therefore exercise more care when the area is enclosed. This makes for safety and promotes better work.

Auxiliary equipment used in connection with the operations will not be scattered about the plant where it does not belong.

Flammable liquids inherent with the operations will not be exposed to ordinary ignition hazards prevalent about the shop.

Automatic sprinkler operation will be quicker and more efficient.

Possible failure of automatic sprinklers or special protection to control an incipient fire will be less likely to result in a major sprinkler failure.

Delicate or costly equipment or stock in the vicinity will not be subject to possible serious and unnecessary damage by smoke, heat, or water from a paint fire.

With proper arrangement of fresh air inlets, entire painting area thus enclosed may be better purged of flammable vapors.

For small parts paint spraying and paint dipping, a special enclosure or room is essential. Locate room at an exterior wall if at all possible, to avoid

too many exhaust openings through the roof, necessitating long lengths of duct. Make enclosure of non-combustible material of at least one-hour fire retardant rating. Floor drainage and curbing are important.

Spark-proofing material should be used for the entire paint room floor; all practical precautions for the prevention of static accumulation should be taken in accordance with the N.F.P.A.'s publication "Static Electricity." Non-ferrous tools should be used, particularly in and around spray booths and dip tanks.

Care should be taken in the matter of supplying fresh air to the room to replace the vapor or residue-laden air exhausted by the spray booth, dip tank and room fans. Suction pipes have but little, if any, directional effect on air currents—the purging action is created by the fresh air inlet streams. A velocity of at least 100 ft. per minute is required to carry away paint residue from spray guns, likewise to insure solvent vapors (wherever created) taking a direct path to exhaust fans without undue dissipation.

If the paint room must be very large, it is necessary to provide additional exhaust capacity in the form of room exhausters, or larger booth exhausters, or both, to build up the total to effect a change of air every three or four minutes.

Ceiling height is a vital factor in paint room economics and safety. Twelve feet is a reasonable and practical maximum height. If main building roof is extremely high, a concrete slab paint room roof is advisable, allowing the space above to be used for storage, fabric cutting or sewing, or some other non-hazardous occupancy. Otherwise a suspended ceiling of at least one-hour fire retardant rating is recommended.

The sprinkler system in the room should conform to rules for extra-hazardous spacing and pipe sizing, with separate control if fed from the main system.

If the sub-assembly paint spraying operation is not too extensive, and there is furnished sufficient booth capacity to insure all spraying being conducted within the booths, it may be carried on with reasonable safety without a special enclosure or room. The booths in this event must be of the water-washed type. It becomes necessary also to provide a separate enclosure or room with a low ceiling, cut off, to take care of the many containers of paints, solvents and cleaning fluids, or paint mixers and agitators usually encountered in this phase. It is imperative that freshly painted sub-assemblies be placed some distance away from the face and sides of the booths and that the number be kept to a minimum.

An area 20 ft. in all directions from the face of the booth is to be considered the hazardous area, and electrical equipment installed therein to be of the type approved for Class I Group D locations, except that ceiling lights in this area, also those over freshly painted parts, may be of the heavy marine or vapor-tight type, and motors may be of the totally enclosed non-sparking type.

In this connection may I say that DC and single (split) phase motors are ordinarily spark producers and if used must be of a type approved for Class I Group D locations.

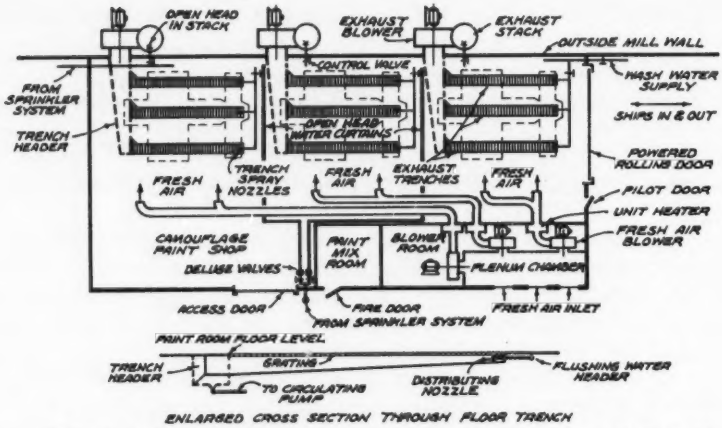
If there is congestion in this department, or the sub-assemblies handled are partly fitted up and therefore represent very high values, then an enclosure similar to a small parts paint room is in order. A room outfitted like an oversized spray booth may be used to take care of the entire sub-assembly finishing job.

The camouflage or complete ship painting phase of work warrants the very best in fire protection, for here a hazardous operation is performed on two or more finished ships at the same time. The number of ships in the area depends of course upon the extent of the paint job and upon the production schedule. The painting time per ship might run as high as 10 to 12 hours. In any event the value exposed might easily be several hundred thousand dollars.

Not only should the operation be in a detached fire-resistive or non-combustible building built for the purpose, or at least in a room of the same character within the assembly building, but provision should be made for confining a fire to one ship. This may be accomplished essentially in only one way with real security and reasonable efficiency, that is, by providing light and movable non-combustible barriers or doors between ships. It will at once be apparent that such a set-up is in effect a mammoth spray booth cut up into several small ones. Each compartment should be equipped with an automatic open head deluge system.

Undoubtedly this arrangement is the ideal from a protection standpoint, for it assures prompt water flooding of an entire ship in case of fire and absolutely confines the fire to the one ship involved. Fortunately it has a distinct advantage from an operating standpoint, for while it is in a way costly and annoying to contend with barriers of this size, it does permit cutting down on ventilation to accommodate the job in hand without sacrificing safety. In other words, if actual barriers are employed between ships, then only the unit in which painting, cleaning or air drying is actually being done requires purging. This is important, for supplying fresh air, tempered and often filtered, especially in cold climates, is a major problem when an air movement rate of at least 100 ft. per minute is required over an entire room cross-section of the dimensions necessary to accommodate several complete ships. When necessary, too, masking, unmasking and other non-hazardous preparatory operations normally carried on in limited areas and without special ventilation may be shifted over to the hazardous sections and their blowers shut down, thus accomplishing economy.

It will be apparent that head room must be kept to a very minimum, for every square foot of room cross-section means 100 cu. ft. a minute of air to be conditioned and moved.



ENLARGED CROSS SECTION THROUGH FLOOR TRENCH

Well adapted on a smaller scale for doping is this alternate method of ship paint room. Ventilation is downward, with water-washed trenches. Protection, with low ceiling, may be by closed heads, with automatic water curtains or barriers between units.

The movement of such large quantities of air requires care in balancing pressures so that the necessarily large doors between compartments—or between the main factory and spray rooms if the area adjoins the factory or is within the factory—may be of reasonably light construction and withstand pressure differentials within reason that might occur. This is to say that it will be found necessary to supply fresh air for each compartment at approximately the same rate the exhaust blowers evacuate it.

Any concealed space above the paint room ceiling (which should be tight) should be kept at a slightly positive pressure to avoid infiltration of vapor or paint residue into the space. This may readily be accomplished by introducing fresh air from the input blowers by auxiliary connections to the pressure ducts, and venting the space to atmosphere without auxiliary exhausters.

The concealed space must not be used for storage nor contain any combustible material or equipment. Automatic sprinklers in the space are not required, although any self-cleaning filters installed therein should be provided with a satisfactory automatic extinguishing agent in accordance with the rules.

Water-wash precipitation of the paint residue for each compartment should be required. Water flow in each case should be interlocked with the compressed air supply for spray guns in such a way that painting may not be carried on without the water-wash. A pressure device for this purpose, installed in the water supply line on the nozzle side of all shut-off valves, rather than a connection to the water pump control circuit, is recommended.

Both fresh air and exhaust blowers likewise should be interlocked with the spray gun compressed air supply.

Deluge valve heat-actuating devices should be utilized also to trip out all fresh air blowers in the area—but not the exhaust blowers—in case of fire.

In general all electrical equipment both for lighting and power in the paint room proper should be of a type approved for Class I Group D locations. Motors in the fresh air supply equipment, also those which may be in ventilated compartments or otherwise located so that they will not be subjected to flammable vapors at any time, may, however, be of the totally enclosed, air-cooled, non-sparking type.

The use of any heat or spark producing apparatus in the area should be strictly prohibited.

Under no circumstances may a fueled plane be taken into the paint room.

All ships should be grounded by use of cables and connections provided for the purpose, before any painting work is started. Clamps should be of the type made fast by a bolt or wing-nut, rather than of the spring type.

An alternate method, but perhaps less positive, is that of providing ordinary closed head wet pipe automatic sprinkler system in the area (without physical barriers), augmenting this protection by providing an automatic water barrage between ships by the use of open heads on pipe lines controlled by small rate-of-rise heat-actuated deluge valves.

Choice of the method of protection to be used as described in the foregoing depends upon many factors, the principal ones being the size and height of the paint shop and adequacy of the available water supply.

The interior ship painting operation presents not only a fire hazard but a severe explosion hazard, for unless solvent vapors can be carried away as fast as formed, explosive mixtures may collect and be confined in the many compartments of the hull. It therefore warrants the utmost care in special ventilation and removal of every possible source of ignition.

If possible, interior spray painting should be carried on outdoors. If indoors, it should be done in the camouflage paint shop or in a spray booth. If no paint shop or booth capable of accommodating a ship is available, then a special exhausting rig should be provided, with suctions connected to various compartment hatches on the ship, and exhausting to atmosphere.

In any event portable fresh air blowers with flexible discharge tubes should be provided to connect to and pump fresh air into blind spaces which would not otherwise be purged by the suction blowers. Bilge and wing compartments may be particularly vulnerable in this respect.

Doping operations should always be enclosed. Safety is largely a matter of ventilation and cleanliness. Construction and equipment for the dope room should follow along the same lines as those for the small parts spray room previously described, except that sprinkler protection should be by means of open heads, rate-of-rise operated. The room may be ventilated by sweeping it with

fresh air as outlined or by employing a floor duct system with exhausters over which the surfaces may be placed for brushing.

As to the paint mixing operations, large quantities of flammable liquids are handled and often exposed. Whether extensive or of small proportions, the room should by all means be enclosed, by a masonry wall preferably, but at least by an enclosure of two hours fire retardant rating, and if possible outside any main building.

The previously described rules for small parts paint spraying and paint dipping rooms as to drainage, spark-proofing, electrical work and ventilation should be strictly adhered to.

Particular emphasis is placed upon the need of removing every possible source of ignition. Air operated hoists and agitators are recommended. If possible, motors operating drum rollers and tumblers should be located outside the room, driving by low-speed shafts through the wall. Grounding of agitating tanks and drum racks is especially important. All rolling drums should be of bare metal to insure contact with the grounded rollers or with the special contacting rollers or chains.

Mixing rooms, too, should properly be protected by automatic open head sprinklers, rate-of-rise operated.

Hangar Protection.

The occupancy of a hangar varies considerably with the type of ship produced, purchaser's requirements, plant facilities, etc., ranging from substantially dead storage to full-fledged experimental with machine shops and servicing of all kinds. Engines are never operated in a hangar.

In general, safety measures listed under "Ground Testing" apply here.

All spark-producing equipment such as MG sets, vacuum cleaners, etc., should be segregated wherever possible in a well-ventilated service room for the purpose, where there would be little or no possible chance of flammable vapor accumulations.

Electric service outlets in pits in the floor or close to the floor, carrying current from special generating equipment or from regular power lines, should be limited strictly to the type for Class I Group D locations. Any storage batteries which must be used close to ships should be placed on rigid stands well above the floor (never on the floor), the terminals protected, and cables securely attached.

All electric extension cables and appliances to be of the type for Class I Group D locations, regularly inspected and kept in first class condition.

Under no circumstances should ships' fuel tanks be tested with flammable liquids in a hangar.

Ships should never be fueled nor drained in a hangar.

First aid equipment must be abundant and carefully selected.

Floor drainage is important. Drains should be so proportioned and spaced (with sectional pitching) that each drain will be able to carry away approximately 20 g.p.m. of water for every 100 sq. ft. of floor area assigned to it, without spill-over to adjoining drained areas. If hangar adjoins main building, raised curbs should be provided at any protected service door openings, to prevent flow of water from sprinklers or hose streams into main building. Service pits in floors to be avoided where possible, but if necessary, should be as small as possible and not connected together with ducts. Basements should be avoided, but if provided and used for working or storage areas only, should be shut off absolutely from hangar area above and be mechanically ventilated. Under no circumstances should air be circulated from any hangar area to a basement or to any other hangar area. Any fuel burning or electric heater should be located as far away as practical from the hangar proper and in any case, should be securely cut off and remote from the apron and never below grade level.

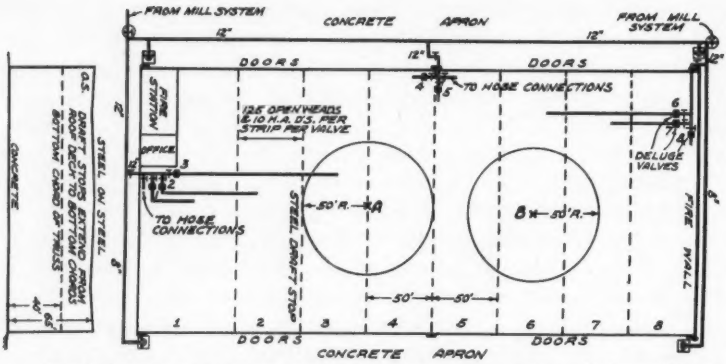
Considering the facts that tremendous values are involved, that ships are difficult to protect with water from automatic sprinklers (the principal automatic method to date), that hundreds of gallons of fuel may be within the confines of the hangar walls (since practically all ships' tanks contain fuel), and that sources of ignition are inherent in the work, even though they may be minimized, it is readily appreciated that hangars in general represent the principal hazard of aircraft plants.

Fire in a hangar will demand a large quantity of water quickly. We must count on a great deal of water wasted—for the ship itself is a weatherproof affair.

Before going ahead with automatic sprinkler system design it is well to recall some of the inherent characteristics of sprinkler operation and some of the lessons long and hard experience has taught. First is the fact that sprinkler heads require some time to operate, and secondly that although heated air rises it also spreads out or mushrooms so that the higher the heads are above the hazard they are to protect, the longer they take to operate.

The antidotes for these drawbacks are: to keep the roof deck as low as possible—or better, to provide a suspended ceiling to allow installation of the entire sprinkler system at a much lower level; to provide deep curtains or draft-stops to bank the heat and confine it to a small area; and to employ rate-of-rise heat-actuated deluge valves to flood sprinkler systems of open heads, i.e., deluge systems.

There are, however, certain disturbing features in connection with the use of deluge systems which must be considered—otherwise such systems would be the logical ones to use in every case, since prompt application of water on any fire is the prime object of sprinkler design. One, and perhaps the most important, is the possibility of clogging branch lines or individual heads by débris upon operation of the deluge valve. The sudden rush of water into an empty

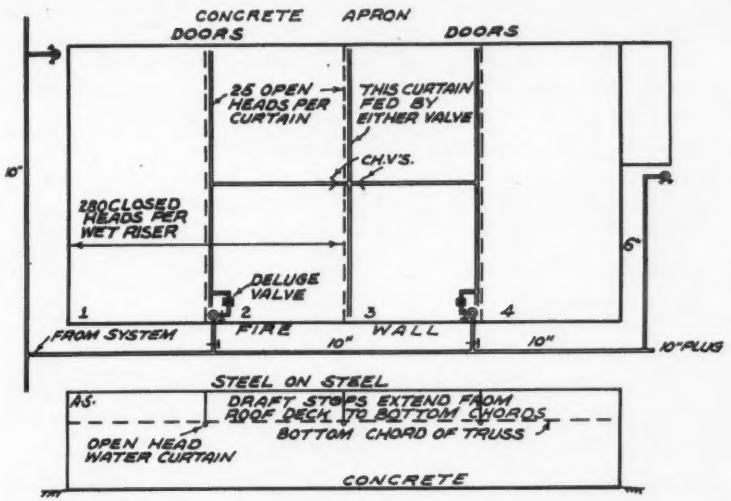


Typical open-head deluge system for hangar protection. A fire might be expected to operate two or three systems as indicated by heat areas above points of origin A or B.

system may take with it pipe scale, barnacles, pebbles, and even larger and heavier foreign objects, particularly when fed by extensive private underground systems or by public water systems. This trouble has long been experienced with dry pipe systems, years before the advent of deluge systems. It is offset to a degree by the oversized piping and closer spacing required by the Standards for just such occupancies. It may be further minimized by strict supervision during installation of both inside and underground work, by care in selecting and guarding the water supply for fire pumps, and by the installation of approved strainers and galvanized pipe.

Another point that must be weighed very carefully is the matter of volume and pressure of water available, both as to primary and secondary sources. Unless enough water is available to take care of all the open heads that are likely to be called upon for a given fire, a sprinkler failure is possible. Figuring on 12 to 15 g.p.m. discharged per head, it is readily seen that in a good-sized hangar a fire might normally cause more than one system of say 100 heads each to operate, and perhaps three or four systems, demanding surely 1200 g.p.m., probably 3600 g.p.m. and very possibly 4800 g.p.m. It would not be safe to figure on less than 4800 g.p.m. from all sources combined, nor less than 1500 g.p.m. from the primary source, for some time-delay should be allowed for getting the secondary or pumping supply into operation, even though one or more units may be automatic.

Delivering such quantities of water to a given point reliably is not a simple problem. It is sometimes not practical, and in rare cases impossible. For example, gravity tanks may have to be limited in elevation and located remote from the hangar; there may be bottlenecks in a public water system far removed from the plant and beyond control of the plant.



With hangar decks not too high, and particularly with exterior doors at one side only, reasonable protection may be secured by employing standard closed head systems with deluge water curtains for segregation. Note the use of check valves to reduce the number of deluge valves required.

Another method of securing dependable hangar sprinkler protection, especially with ceiling heights not over 35 or 40 ft., is that of installing standard closed head wet pipe sprinkler systems augmented by rate-of-rise heat-actuated water curtains in conjunction with draft-stops so arranged that a fire at any point will immediately operate the deluge valves and by means of the curtains lay down a barrage of water around it, leaving the automatic sprinklers within the area involved to operate as required.

Ordinarily when hangars are 15,000 sq. ft. or less in area, and ceiling height is less than 35 ft., closed head wet or dry pipe systems alone may be employed. The use of pre-action systems, i.e., rate-of-rise heat-actuated deluge valves controlling closed heads, may be used in lieu of dry systems.

All deluge-valve-controlled systems should be regularly inspected and serviced by reliable servicing companies.

Standards for the Protection of Hangars as published by the National Board of Fire Underwriters should be followed in any case.

Summarizing on hangars, I would like to make the following comments:

Limit the height so far as possible.

Provide non-combustible hung ceilings if possible.

Limit area to 50,000 sq. ft. Division walls to be standard brick or concrete. Door openings in division walls to be protected by

double standard automatic sliding or rolling fire doors. If possible, arrange "H.A.D.'s" to operate doors in addition to fusible links.

Concealed space above a hung ceiling should be sprinklered if roof deck or supports or hung ceiling rafters are combustible. No openings should be permitted in hung ceilings.

With any type of system figure 12 to 15 g.p.m. required at a pressure (when flowing the total required amount) of 15 lbs. at the highest head, making allowances for height and long runs.

WITH OPEN HEAD SYSTEMS:

Avoid using over 125 heads per valve.

Single systems should extend from one side to the other (not lengthwise).

Provide non-combustible draft-stops, extending from deck down to bottom chord of truss if possible, but not less than 1/6 of the roof height between systems.

For the water flow requirement, figure the discharge from all heads in system directly over the fire and in those systems within 50 ft. of the fire.

Avoid open head systems if primary supply alone cannot supply one system, or if no draft-stops can be provided in a hangar requiring more than three systems (except if there is no question whatever of the flow available).

WITH CLOSED HEAD SYSTEMS:

Limit the number of heads per riser to 200. Draft-stops should be provided as with open head systems, except that they need not separate systems. Area between stops should be limited to 15,000 sq. ft.

Heat actuators for water curtain operation should be spaced the same as for deluge systems.

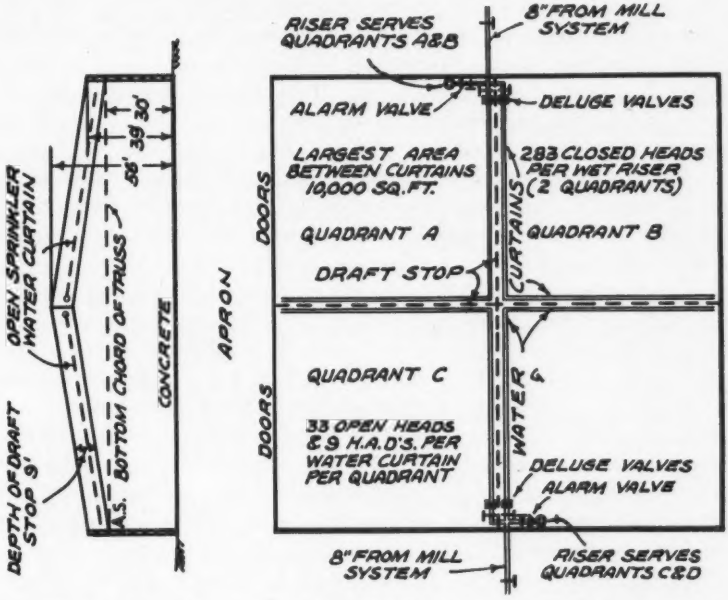
For water flow requirement, figure the following number of heads likely to open in every draft curtained area which is wholly or partly within 50 ft. of a given fire:

Maximum ceiling height not over 25 ft.— 65 heads
Maximum ceiling height 25 to 35 ft. —100 heads
Maximum ceiling height over 35 ft. — 60% of sprinklers

Add the flow for water curtains likely to be operated.

Sprinkler Protection in General.

As to automatic sprinkler protection in general, a careful analysis of the foregoing should reveal the fact that there are indeed few portions of an all-metal aircraft factory in which combustible material in one form or another is not present. Moreover the fire protection engineer and owner alike well know



Illustrating another method of combination closed and open head systems. Here a deluge valve serves to segregate each quadrant, eliminating waste of water.

that the business is not yet sufficiently stabilized to warrant treatment as a finished unit. In other words, an area or production line devoid of combustible material and apparently not requiring automatic sprinkler protection today might be full of such materials and demand sprinklers tomorrow. Such a change may come about in many ways—as for instance, a sudden expansion program requiring complete re-routing of processes; a change in ship design resulting in similar changes in production lines; a change in materials used in ship construction or in equipment to build them.

These possibilities, coupled with the facts that extensions to a partial sprinkler system are costly—that the sprinklers themselves and the inside piping to supply them usually form but a small proportion of the total cost of automatic fire protection—that a possible plane crash on the roof of a large building might result in a conflagration of burning fuel within the building—all make for a complete sprinkler installation from the start.

It must be remembered that any saboteur worth his salt knows the weak spots in fire protection above all, and the final measure of security for the plant owner and our Nation consists in eliminating as many weak spots or loopholes as possible. Spot-sprinkler systems in fire-resistive or non-combustible buildings therefore should not be relied upon.

Water Supplies.

As to water supplies, the choice of a primary supply, that is, the source that maintains a constant pressure on the system without the use of mechanical devices, is rather simple, for there are only three available, namely, connections to public water mains, elevated gravity tanks (or reservoirs), and pressure tanks.

Actually there are only two sources to choose from—public water or gravity tanks—for pressure tanks are intended for plants of small area, usually city properties, and have no place in this phase of fire protection work owing to their limited capacity.

If public water is available, then the volume and flowing pressure necessary to qualify for a primary supply become vital factors. The question of initial or static pressure is of relatively minor importance compared with the question of residual pressure obtaining during the flow of the required volume at the time of a serious fire. For the average modern plant of about 50 ft. in height, disregarding, for the moment, the draught required for automatic sprinklers to cover special hazards, but figuring on supplying say 30 heads and perhaps two hose streams until such time as the secondary or pumping supply may be placed in service, 50 lbs. should be the very minimum at grade level when supplying the approximate 1000 to 1500 g.p.m. required.

While the magnitude of the plant as a whole influences, to some extent, the size of both primary and secondary supplies, the real factors in determining the rate of flow are the vital spots or hazards in the plant, such as hangar, ship painting, small parts spraying—perhaps the dope room or paint storage area. Every such spot should be separately analyzed, therefore, to determine how much the above mentioned minimum (as to primary supply) should be raised to fit the plant, tempering the results by a careful consideration of any probable expansion program.

In most cases, using this method of analysis, it will be found that the minimum flow of water required (and immediately if open head systems are involved) is around 1500 g.p.m., and the pressure sustaining this flow at grade level and at a point near the principal hazard area should be 50 lbs. or more. With deluge systems involved it will be apparent to the engineer that any less water available from the primary source might under unfavorable circumstances result in a sprinkler failure. Automatic boosting of pressure from public mains may, it is true, make up for some deficiency in respect of pressure (when the volume is good but the static pressure is low), but such a corrective measure should be employed only as a last resort.

In the case of gravity tanks as the primary source, the capacity should be governed by past experience in other industries, size of the plant, extent of the underground system and reliability of the secondary supply.

The elevation of a gravity tank should be not less than 50 ft. above the highest line of sprinklers or 100 ft. from the ground, and preferably not less than 125 ft. from the ground. This additional height is particularly desirable to counteract friction losses when long runs of underground pipe are encountered between the tank and the principal hazard or where it is impossible to secure satisfactory underground loop mains.

To secure an extra measure of flexibility it is desirable to split up a very large tank capacity into two units, each feeding the system at widely separated points. Such a plan permits of repairs or painting of one tank at a time without seriously impairing the plant protection.

The secondary or pumping supply as to rate of flow is readily arrived at. To some extent it is influenced by the adequacy of the primary supply and by the magnitude of the property in general, but it must be able to supply the greatest number of sprinklers likely to operate on a given fire, plus an ample amount for hose streams or other contingencies. Pumping capacities for modern plants range from 3000 to 8000 g.p.m., broken up into several units.

The quantity of water necessary to feed the pumps (suction supply) is a matter requiring considerable deliberation, and although it depends to a certain extent upon the nature of the primary supply, the magnitude of the property, the amount of combustible material in construction and occupancy in general, and other factors, the likely pumping time required to cope with any fire is the determining factor. Experience and judgment point to a period of at least three hours as a minimum when an unlimited supply is not available.

The choice of prime movers for pumps and the number of units to make up the total requires a careful study of local conditions and facilities. Electric and steam driven centrifugal fire pumps are most commonly used. Automatic control of either is comparatively simple, although there are certain more or less fundamental rules to follow, particularly with electric units, to accomplish reliable operations in practice.

N.F.P.A. and N.B.F.U. standards for Centrifugal Fire Pumps should be followed in detail in every case.

Underground System Design.

Design of the underground supply system follows along the lines of standard modern practice in other industries, except perhaps that more care must be taken in pipe sizing to provide for possible heavy drafts of water for open head systems.

Loop systems or the equivalent around main buildings and hangars are quite necessary, to cut down friction losses and enable water to be routed to any point in two directions. This lends flexibility to the entire system in that it permits, with proper valving, water to remain on the bulk of the system in case of a break at any point or when repairs or alterations are being made.

Where sections of a loop must pass beneath a building (which is undesirable), a sectional valve should be provided at either side.

Sectional or divisional control valves should be placed in the loop at either side of each water supply connection and at points along its path preferably so that not more than four sprinkler riser connections will fall between valves. With a typical city gridiron system, sectional valves should be provided in all branches at each intersection.

Post indicator valves controlling sprinkler risers should be kept at least 40 ft. from the building involved where possible. Near hangars, on aprons or ramps, or other areas where such projections would constitute a hazard to ship traffic, post indicator valves may be grouped and located at protected spots close to buildings.

Hydrants should be well away from buildings and spaced not over 300 or 350 ft. apart. Flush-type hydrants may be resorted to for aprons where necessary, but only in moderate climates.

Conclusion.

Many of the opinions and suggestions appearing here reflect the writer's personal views based upon experience in the field covering a period of many years. They should not therefore be taken to mitigate any detailed local ordinance or underwriters' rules.

I would like to point out again in conclusion that many of the limitations and suggestions outlined in this discussion are predicated upon present-day practice in construction of plants and ships, that is, buildings of heavy construction, largely non combustible, and ships of metal.

If it becomes necessary to engineer fire protection for light combustible buildings and for wood, plastic, and fabric ships, as the trend seems to be, the picture is changed in many respects, for the spread of fire under such conditions might be so rapid as to void some of the theories expressed. Certain it is that areas subject to one fire should be cut down, fire walls and special hazard enclosures made heavier, water supplies bolstered up, and the use of open head deluge systems extended.

The fire record in the industry to date has been good, especially in view of the forced conditions under which it has had to operate. Let us hope this record continues—that the law of averages does not bear down too hard.

Luminous Paints.

In view of the current situation, considerable interest has been expressed in methods of identifying fire extinguishers, hand hose, fire alarm boxes and other fire protection equipment during blackouts. One method which has been advocated is the use of luminous paints. The following information, extracted from the National Bureau of Standards' Letter Circular No. LC678, may be of interest in this connection.

There are two types of paints designed to emit light under certain conditions, luminous and fluorescent. Luminous paint may be classified into two groups, one designated as phosphorescent and the other as radioactive. Phosphorescent powder or paint, after exposure to ultraviolet or visible radiant energy, may continue to glow for a few minutes to several hours in the dark, and may be reactivated by exposing it again to the exciting stimulus. The radioactive paint does not require any such exposure, but will continue to glow due to the radioactive material it contains.

The phosphorescent type may contain for a base specially prepared impure sulfides of calcium, strontium, barium or zinc, or mixtures of these materials. Phosphorescent paints do not contain phosphorus, as luminous paint cannot be made from this substance because it is dangerous to work with.

The phosphorescence of this type of paint is due to traces of certain elements such as copper, bismuth, lead, cadmium, manganese, cobalt, nickel, etc., and these also impart a characteristic color to the basic material. Phosphorescent pigments are relatively coarse and any attempt to grind the pigments to a fine state is apt to result in greatly decreased phosphorescence.

Certain pigments which have a relatively intense initial brightness during irradiation have a shorter time of useful afterglow (usually two hours or less). Zinc sulfide and zinc-cadmium sulfide are illustrative of this property. In contrast, the alkaline earth sulfides, for example, luminous-calcium sulfide and luminous-strontium sulfide, have a lower initial phosphorescent brightness but a longer useful afterglow (usually from two to twelve hours).

In the manufacture of phosphorescent paint, the ordinary varnishes and most drying oils are not suitable liquids. The usual metallic driers will also often give trouble. The liquid must be practically neutral and in some cases must be selected with the pigment in mind with which it is to be used. Cellulose lacquers, spirit varnishes, dewaxed damar varnish and vehicles prepared from plasticized chlorinated rubber, cyclohexanone resin, vinyl resin and polystyrol resin, suitably plasticized, may be used. Polystyrol resin, plasticized with dibutyl phthalate and dissolved in xylol, is said to make one of the best vehicles for phosphorescent paint for outdoor use.

In applying phosphorescent paint, a special white primer or undercoater paint composed of titanium oxide should be used on the clean wood, metal or fabric surface. After this is dry the phosphorescent paint is applied. If thinning is necessary, a special thinner provided by the manufacturer should be used. Care should be taken that a clean and dry brush is used with each paint. After this paint is dry, a special varnish supplied by the same manufacturer is sometimes necessary to protect the luminous paint from moisture and the weather. The surface to which the phosphorescent paint is applied may affect the luminosity of the paint. Therefore, the surface must be clean, dry and neutral to the paint.

Due to the fact that this paint is relatively expensive, that the afterglow is of relatively low brightness and may be best appreciated in *complete* darkness, its use is most effective indoors or in nearly complete darkness, such as light switches, stair treads, shelter entrances, door knobs, etc.

The luminous paints used for painting number or letters on watch and clock dials, compasses, etc., contain a minute amount of radioactive substance such as radium or mesothorium on a responsive base, usually zinc sulfide. The amount of radium required is very small and its purpose is to excite the base continuously so that no exposure to radiant energy is necessary. A paint of this type is more expensive than the phosphorescent type and the radioactive pigments have caused serious injury to factory workers. Therefore, extreme caution must be employed in preparing them.

In addition to its use in a paint, the radioactive pigment has sometimes been placed between two disks of transparent synthetic resin plastic, in the form of "buttons" about one inch in diameter, which are used as guide markers on a road during blackouts.

The principal distinction between fluorescent and phosphorescent materials is in regard to the length of time that light is emitted after removal of the exciting source. Fluorescent materials emit light only during irradiation, and it is upon this property, together with the fact that they may be irradiated by ultraviolet energy, popularly known as "black light," that their usefulness depends. As with phosphorescent pigments and paints, emission of light of various colors is possible with a given exciting source, depending on the nature of the material. Some of the more common pigments used in fluorescent paints are zinc sulfide and zinc-cadmium sulfides. A typical fluorescent pigment is zinc sulfide activated with a small amount of copper.

The same general considerations which govern the application of phosphorescent paints apply as well to fluorescent paints.

Fluorescent materials are best suited for use where positive illumination of detail in darkness is required, as in the case of instrument dials in airplanes,

printed maps, train schedules, printed signs, etc. The printed material may be produced commercially in large quantities. All of these may be read in the dark by means of small commercially available "black lamps" such as 2.5 watt argon lamps and other types of black light sources. Phosphorescent and fluorescent pigments and paints are also commercially available as well as fluorescent plastics, cloth, paper, carpets, etc.

Rubber Still Burns.

This interesting picture of a fire in San Jose, California, on May 8, by F. W. Hadley of the *Mercury Herald,* presents a typical example of how the nation is still burning up its precious supplies of rubber. Fires such as this do not attract national attention as did the famous fire in Fall River, Mass., last October, but the aggregate loss of tires and other rubber stock in a multitude of small fires throughout the country has a most serious aggregate effect. In this building there were stocks of new "frozen" tires, tires awaiting retreading and retread material. The proprietor had closed the shop for the night five minutes before the fire was discovered. He said he had no idea how it started. The loss was estimated at $75,000.

Water Spray Protection.

By H. S. Hirst,
Factory Mutual Laboratories.

In 1935 a paper on "The Use of Water to Extinguish Oil Fires" was presented at the N.F.P.A. Convention. Up to that time a very limited amount of work had been done in developing water spray nozzles for the extinguishment of fires in high flashpoint oils. In 1938 the Convention was again addressed on "Portable Water Spray Nozzles," and colored motion pictures of test work that had been done during 1937 and 1938 at the Factory Mutual Laboratories with portable spray equipment were shown. It is the purpose of this paper to review briefly previous work done with both permanently piped installations and portable water spray nozzles and to discuss recent applications of spray nozzle protection which are fast putting this type of equipment on a par with existing types of special extinguishing equipment, such as foam and carbon dioxide, and which may in the not too distant future enter parts of the field now held by the automatic sprinkler as protection for buildings and their contents.

Actual extinguishment of oil fires by water spray is probably due to a combination of factors, each having a varying effect for any particular fire. Among these are cooling, exclusion of oxygen, formation of a non-combustible emulsion and dilution in the case of water soluble liquids such as alcohol.

Types of Spray Nozzles.

To produce a spray that will extinguish fires successfully, several spray nozzles have been developed and these are of two general types with respect to the spray produced, high velocity and low velocity. Two types of approved high velocity spray nozzles produce either a hollow cone or solid cone spray. In the first type, such as the American-LaFrance "Poweron," water passing through the nozzle flows past four fixed vanes, between a constriction and a deflector, finally diverging while passing out between the end of the nozzle and the rounded outer edge of the deflector. The divergence of the water and the resulting turbulence break up the stream into a high velocity spray with a narrow angle hollow cone. The solid cone spray nozzle has a central jet which is broken up by several swirling streams that converge within the nozzle upon the central jet just at the orifice exit. Representative nozzles of this type are the Grinnell "Mulsifyre" and Spraco or "Automatic" "Fire-Fog" which are used for both fixed installations and portable equipment.

This article was presented as an address at the 46th Annual Meeting of the National Fire Protection Association, Atlantic City, May 11-14, 1942. It is printed in the QUARTERLY to permit the inclusion of illustrations. For discussion see Proceedings, page 127.

Low velocity spray nozzles that produce a spherical ball of spray or any desired solid geometrical figure without the directional characteristics of the high velocity type are of two general classes. In the first the spray or fog is formed by the impingement upon one another of the streams of water from a pair of orifices outside the nozzle. Usually several pairs of orifices are provided in the nozzle casting. The Fog Nozzle Company's "Fognozl" and Rockwood Sprinkler Company's "WaterFOG" heads are representative of this class. The other class is internal impingement nozzles wherein two intersecting ports within the nozzle allow the water streams to impinge upon one another before emerging from the nozzle casting. Several pairs of internal impingement ports are usually provided. This type of nozzle is also manufactured by the Rockwood Sprinkler Company and may be altered in design to give a high velocity spray. All approved types of spray nozzles for piped installations are of the open type with the water control in the supply line.

In general, a high velocity solid cone spray has a considerable range and, at the same time due to the formation of the solid cone, the water particles have a tendency to carry air along with them so that a draft is created. The low velocity spray has but little directional characteristic and consequently does not tend to create an air draft. However, the range of the spray is less than that of the high velocity solid cone.

It is possible to create the low air draft and low range effect of the low velocity spray by impinging two high velocity solid cone sprays upon one another above the surface to be protected.

General Applications and Limitations.

Permanently piped installations and portable water spray nozzles are in general suitable for protection of flammable liquids having flashpoints of 150° F., or greater, such as industrial fuel oils, transformer oil, kerosene, flushing oil, lubricating oil and asphalt.

Certain types of approved nozzles may be used successfully in extinguishing non-miscible flammable liquids with flashpoints between 100° and 150° F., such as safety solvents, mineral spirits or Hi-Flash Naphtha. Extinguishment of this type of fire is more difficult than with the higher flashpoint materials. Flammable liquids having flashpoints below room temperature and a high viscosity may also be successfully extinguished by water spray. Viscous paints and rubber cements with benzol thinner are representative of this class of material.

It is sometimes possible to extinguish low flashpoint flammable liquids such as gasoline in small metal containers if a high freeboard is maintained and if the entire area can be covered with one nozzle of the low velocity type. The formation of steam by water striking the hot metal sides of the container plays an important part in extinguishment, the sudden cloud of steam formed when

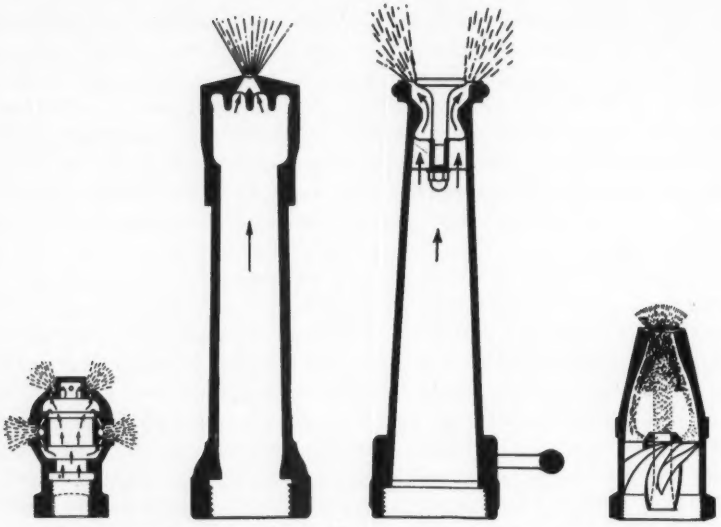


Fig. 1. Four types of approved spray nozzles. From left to right: Low velocity external impingement, low or high velocity internal impingement, high velocity hollow cone, high velocity solid cone.

the nozzle is first applied smothering the fire within a very few seconds. A few tests have indicated that low flashpoint water soluble liquids such as alcohol may be extinguished with water spray, one effect being the dilution of the alcohol to a point where combustion no longer continues.

However, actual extinguishment of either alcohol or gasoline fires is largely impractical with the present types of spray nozzles now available, although spray application does reduce the intensity of the fire considerably and will keep surrounding equipment cool.

Both fixed installations and portable water spray nozzles have their limitations as do any types of fire extinguishing equipment. In general, water spray is not suitable for use on fires in open tanks of flammable liquids the whole body of which is heated above 250° F., since the introduction of spray causes formation of steam under the surface of the oil, resulting in a boil-over of the contents of the tank. Although the fire in the tank may have been extinguished by the water spray, if an ignition source is present outside, re-ignition is likely to occur during the boil-over. This hazard can be overcome, however, and adequate protection provided if means are taken to confine the boil-over such as by pits or shallow dikes and if the spray protection is extended to the surrounding area.

The most important advantage of water spray equipment is that the supply of extinguishing agent is relatively inexhaustible. Carbon dioxide, foam or

dry powder extinguishers of either the permanently piped or portable type generally have but limited capacity; and if the fire, through some unforeseen occurrence, should not be completely extinguished when these types of extinguishers are exhausted, nothing more can be done unless some form of reserve equipment either in the nature of additional extinguisher capacity or water is available. Water spray, either permanently piped or portable, is of course subject to the same water supply limitations as automatic sprinklers or hose streams, but under usual conditions the supply may be considered practically inexhaustible.

It has been proven in tests that, gallon for gallon, water from an approved spray nozzle is a more effective cooling agent than water from a sprinkler head on the same type of fire, due to the finer atomization of the water and more uniform distribution. Assuming average water pressure available, an automatic sprinkler system installed for protection of ordinary combustible material gives a water distribution on the floor of from ⅛ to ½ a gallon per square foot per minute. However the usual type of spray nozzle installation is designed for the protection of a special hazard more serious than ordinary combustible material and requires a considerably higher rate of water application for the hazard protected, perhaps as high as two gallons per sq. ft. per minute for some types of flammable liquid fires.

Present approved types of spray nozzles are designed for specific protection of a horizontal or vertical surface toward which they may be aimed, whereas part of the discharge of the automatic sprinkler is thrown against the ceiling, then drops to the floor by gravity and the remainder is thrown toward the floor in a more or less uniform circular pattern. The sprinkler is designed for general protection service and the spray nozzles at present available are designed for special protection; use either for the opposite application and the efficiency is less.

Because of the fine particles of the water spray, large quantities of heat can be absorbed and it is also possible to wash out of the air a considerable volume of smoke particles. This reduces damage to surrounding equipment by keeping it cool and tends to prevent soot deposition which is particularly important around exposed high voltage electrical equipment.

Many tests have been made with water spray nozzles to determine the electrical conductivity of the spray and it has been proven beyond any question that the broken up particles of water will not transmit current to ground, thus making such equipment relatively safe around live electrical equipment. One test with a portable spray nozzle at a pressure of 20 lbs. per sq. in. located 10 ft. from a charged screen at which the stream was directed gave no measurable current flow to ground through the nozzle with a voltage of 250,000 applied to the screen. For permanently piped installations around transformers certain minimum clearances between live electrical parts and the nozzles have

Fig. 2. Use of high velocity type portable spray nozzle on fire in open pit of fuel oil.

to be maintained, but these are largely based upon the standard air-gap breakdown distance between current carrying parts and the grounded piping and nozzles.

Portable Spray Nozzle Applications.

One of the specific applications of portable spray nozzles is the extinguishment of fire in open tanks of flammable liquids of the types previously mentioned if the tanks are not too large to prevent easy extinguishment of the fire with the particular nozzle used and if such tanks would be accessible at the time of fire. If indoors they must be in large areas with high ceilings so that evolution of smoke and heat will not prevent access to the tank. There have been a considerable number of fires in quenching oil tanks where adequate protection was not provided in the first place and employees unsuccessfully used other types of extinguishers, which either were improperly applied or were of insufficient capacity for the hazard involved to extinguish the fires. Public fire departments have been called and they have used portable spray nozzles, extinguishing the fires with comparative ease.

Portable spray nozzles of the short playpipe type are very useful on oil filled electrical equipment such as transformers, oil switches and high pressure oil piping around large generators. In such cases high flashpoint oil only is

Fig. 3. Fire similar to Fig. 2, using low velocity portable spray nozzle with ten-foot applicator.

involved and although it may be hot, the fire is usually in a thin film of flowing oil which is readily cooled and extinguished.

Portable spray nozzles may be used around live electrical equipment with considerably more safety than a straight hose stream, although, if possible, all electrical current should be shut off before using spray nozzles. Portable applicators 6 ft. or 10 ft. long, to which a spray nozzle is attached, are not considered suitable for use around electrical equipment, not because of the possible electrical conductivity of the spray, but because of the possibility of the operator accidentally touching current carrying parts with the metal applicator itself. Some applicators with insulated sections have been used, but their safety is still open to question.

Fires in ordinary combustibles can of course be extinguished by the water spray if the fires are not of deep-seated origin and if not too large to prevent effective approach. Fires in cotton in opener and picker rooms have for many years been extinguished by the ordinary garden hose spray nozzle with great success, whereas a straight hose stream merely blows the cotton about and spreads the fire.

Confined fires in practically any type of material may be controlled if not extinguished by portable spray nozzles in which the heat absorption, cooling effect and steam formation play important parts. Public fire departments use them constantly for small dwelling, attic and basement fires where heat and smoke are concentrated, as the cone or ball of spray affords considerable protection to the operating personnel.

Portable spray nozzles in general have a considerably shorter stream range than corresponding sizes of straight stream nozzles. This short range limits the size of fire that may practically be controlled, especially confined flammable liquid fires; *first,* since it is essential to be able to reach practically all points of the fire with the spray from one location; and *second,* since a large fire radiates more heat and close approach cannot be made. With hose streams having greater range this is not so important, but for spray nozzles considerably closer approach must be made to use the spray effectively.

Permanently Piped Spray Applications.

Permanently piped installations of spray nozzles have been used extensively in the past few years for the protection of oil-filled transformers. It is estimated that there are now more than ten million kilovolt amperes of transformer capacity protected and more is being protected every day. The amount of fire experience that has been made public is small, but information that is available indicates that these systems are very effective on transformer fires.

When a transformer fire occurs, that transformer in which trouble develops is in many cases severely damaged instantly before the protection can be turned on. However, when transformers are sufficiently large the cost of water spray protection for the transformer on fire may be more than offset by the difference in cost between repairing a damaged transformer without spray protection and repairing the transformer that does have spray protection.

Many transformers are installed in groups of three in conjunction with three-phase electrical equipment and when one of the transformers has trouble resulting in fire, spray protection will in most cases prevent damage to the adjoining transformers. Water spray protection is also desirable for transformers located indoors when not enclosed in a vault or when located outdoors near other valuable equipment, combustible building walls, or unprotected windows through which fire could spread to the interior of buildings.

Transformers of the outdoor or waterproof type are no more subject to water damage from spray nozzle equipment than from a heavy rainstorm. Indoor transformers that are not waterproof are generally protected with manually controlled water spray protection. This is used only when it is evident that the fire damage will be more severe than the damage caused by water entering the transformer shells of those not actually on fire, which necessitates filtering the oil afterward to maintain the necessary dielectric strength.

A very important consideration in transformer protection is the reduction in interruption to service when spray protection is available to lessen the damage. At the present time, especially, new transformers are difficult if not impossible to replace without a high priority, and even then such equipment cannot be obtained for several months. Repairs to existing transformers can be

made in a shorter time than it takes to obtain a new one; and the less the damage the shorter the interruption to vital processes that depend on electric power for operation.

As previously mentioned for portable nozzles, permanently piped installations are suitable for use around oil switches in cabinets and oil piping in the open or in trenches or tunnels, especially where the use of portable equipment is largely impractical because of inaccessible enclosures.

Protection of dip tanks or other types of tanks containing high flashpoint flammable liquids or viscous liquids with low flashpoint thinners is feasible, although relatively few such installations have been made up to the present time, probably because many dip tanks contain low flashpoint liquids for which spray protection is not particularly suited. In such installations an important factor is the provision of a sufficient number of proper size overflow drains discharging to a safe location.

Several installations of piped spray protection have been made on quenching oil tanks, open impregnating tanks and asphalt tanks. No noteworthy fire experience has as yet developed from these installations, but there are a large number of quenching oil tanks now in use and with increased war production of steel equipment it is likely that many more will soon be in use. Therefore, it is reasonable to expect that within the next few years more actual fire experience may be developed.

Dryers or ovens in which combustible material is processed are adaptable to permanently piped spray protection, wallboard dryers being one example of this class. A dryer of this type has had several fires since spray protection was installed and it is reported that the fires have been promptly extinguished in each case.

One of the most important problems from an industrial fire loss standpoint are ducts that may become filled with flammable deposits which, when ignited, are difficult to extinguish because of the inaccessibility to portable equipment. Such fires either result in the destruction of the duct by fire, or render complete dismantling or destruction by fire fighters necessary to complete the extinguishment. A few piped spray nozzles in such ducts or stacks have proved of value in several cases by promptly extinguishing fires in deposits and minimizing damage to the ducts. The problem of external loading of the spray nozzles in such installations is ever present, and frequent cleaning is necessary, although it is possible to protect the nozzles from loading by suitable caps or covers that will blow off when the water is turned on.

Coating machines with horizontal or vertical dryers in which relatively small amounts of flammable liquids may be used as solvents for coating combustible material are adaptable to spray protection. In many instances the liquid used has a low flashpoint so that the actual solvent fire may not be extinguished, but the amount of the solvent is usually quite small and the spray

Fig. 4. Flow test of an installation of permanently piped spray protection for large size outdoor transformers and oil switches.

nozzles are of primary value in extinguishing the fire on the coated material and in keeping the coating and drying equipment cool to minimize damage. This type of installation also has been used successfully in pyroxylin sheet coaters where solvents as well as the extremely flammable pyroxylin are handled. By a closely spaced deluge system of spray nozzles actuated by special types of automatic control devices that operate very rapidly, it has been found possible to cut off the spread of fire through the pyroxylin sheet, and to prevent destruction of a greater part of the pyroxylin passing through the equipment.

It is understood that there is at least one spray installation for protection of airplane engine test cells and although available information is slight, there is reason to believe that such protection will be of value in minimizing damage to engines.

To obtain sufficient atomization for effective operation, a flowing pressure of at least 30 lbs. per sq. in. at the nozzles is the desirable minimum operating pressure, although for flammable liquids of low volatility lower pressures may be used. This means that with a considerable number of spray nozzles and long lines of yard piping to the point of supply, high pressures are necessary at the supply to maintain 30 lbs. per sq. in. flowing pressure at the nozzles. Booster pumps for piped water spray protection may be necessary in some plants where there are small yard mains creating excessive friction loss or where there is a low static pressure to begin with.

Fig. 5. Experimental test of piped spray nozzles for protection of a small transformer. Hot oil pumped from top of transformer shell and ignited.

The chief disadvantages of spray nozzles used in permanently piped installations are the possibilities of external loading from oily or dusty deposits and internal plugging from foreign material that may be in the piping and carried into the nozzles by the water. At the present time practically all approved spray nozzles have orifices and internal passages smaller than one-half inch in diameter (the orifice size of a standard automatic sprinkler). The importance of considering the likelihood of internal plugging or external loading is therefore relatively more important with spray nozzles than with sprinklers and will be elaborated upon later.

Piped Installations.

A piped spray nozzle system consists of the open type spray nozzles now approved, suitably located to protect the particular hazard and well supported. In addition, one or more portable spray nozzles are usually provided as supplementary protection to extinguish fire in flammable liquids or other combustible material that may be beyond range of the fixed protection or as an aid in mopping up the fire and extinguishing the last traces of flame rapidly.

Galvanized piping is used between the spray nozzles and the control valve to minimize in so far as possible scale formation within the pipe which might result in plugging the nozzles.

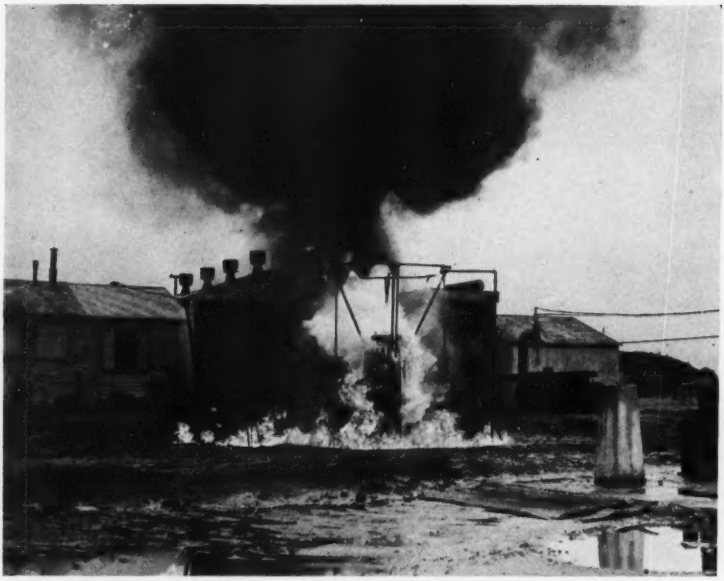


Fig. 6. Photograph taken shortly after water was admitted to spray nozzle system. Note that no direct spray protection has been provided for ground area in this test.

Control for spray systems may be of the automatic type with rate-of-rise controlled deluge valves operated by heat actuators suitably located over the hazard. Fixed temperature electric thermostats may also be used that control an electric release which in turn operates the deluge valve. A third type of control consists of a pilot line of piping with standard sprinkler heads located over the hazard to be protected where they will collect heat readily. The pilot line is under air pressure and is connected to a special type of flooding valve which, when the air pressure is relieved through a sprinkler head opened by the fire, releases a clapper and allows water to flow to the open head system of spray nozzles in a manner somewhat similar to a dry-pipe valve. One manufacturer also uses an individual thermal control valve that is located over the hazard and contains a standard automatic sprinkler link which through suitable mechanical linkages holds a valve clapper closed until heat operates the link. These are made in small sizes and control only a few spray nozzles in the area where the temperature operated element of the valve is located.

Manual control with standard O. S. & Y. gate valves or indicator posts may be used for spray nozzle systems, but where this type of control is used an automatic fire alarm system is usually provided also.

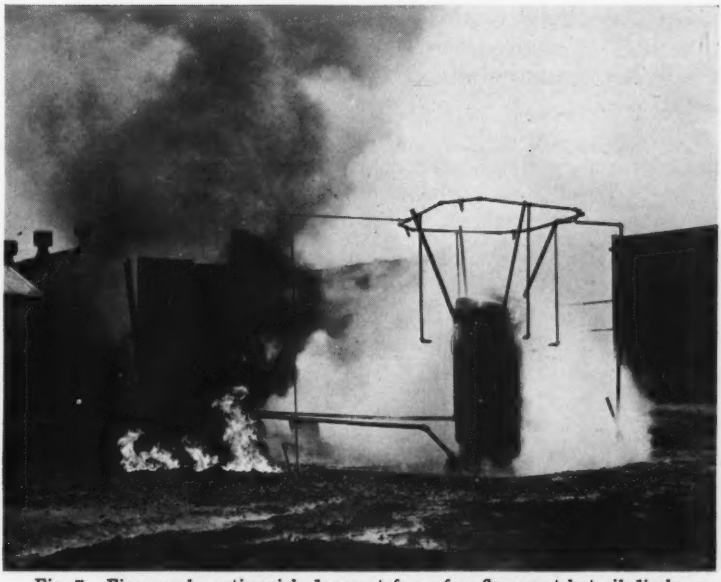


Fig. 7. Fire nearly extinguished except for a few flames at hot oil discharge near top of transformer.

Engineering Requirements.

From the previous discussion of fixed installations of water spray nozzles it is apparent that each installation is a specially engineered job. The effectiveness of water spray protection depends on many factors, such as nozzle spacing, elevation, direction or angle of discharge, water pressure and volume required, wind velocity (for outdoor installations), and the flashpoint, viscosity and temperature of the flammable liquid to be protected, type of construction, overflow drains and possibility of internal plugging or external loading of the spray nozzles. It is therefore difficult to develop simple standards to cover all types of spray nozzle installations. The standards of the National Fire Protection Association for Water Spray Nozzles and Extinguishing Systems are very general in scope and deal only with those relatively elemental factors that occur in practically all installations. The standards are likely to remain in this form for some time to come because of the complexity of the problem.

Further, each type of approved spray nozzle is specially adapted for certain uses and is not suitable for other uses; and the characteristics of the spray nozzles vary between manufacturers. Each manufacturer is familiar with the scope and limitations of his own equipment and is the one best qualified to engineer and install his nozzles. A mill mechanic or plant engineer can follow the relatively simple but definite rules laid down for the installation of auto-

matic sprinklers, but he cannot be expected to be sufficiently familiar with the various spray equipments to make a satisfactory installation. Expert engineering by the manufacturer of the equipment is required.

Discussion of Spray Nozzle Obstructions.

Perhaps the most difficult problem encountered with permanently piped spray nozzle installations at the present time is the possibility of plugging the nozzles by foreign material within the supply piping and the water. For the past seven years the Associated Factory Mutual Fire Insurance Companies have been investigating automatic sprinkler systems for pipe obstructions which at time of fire would cause either partial or complete obstruction of sprinkler heads, resulting in severe impairment to the sprinkler equipment. Plants investigated were selected as those likely to have obstructed systems because of unfavorable conditions of water supply. Obstructions ranging from moderate to severe were found at 74% of the plants visited. Adjusting this proportion on a basis of all plants insured by the Factory Mutual Companies, approximately 17% had obstructions in the piping. From these investigations where material has been found that can completely obstruct the orifice of a one-half inch sprinkler head, it is apparent that the problem can be even more severe for spray nozzle systems, of which all developed for fire protection purposes at the present time have orifices or passages smaller than one-half inch.

At present, approved strainers are considered essential for practically all installations unless it is reasonably certain that the system will not be obstructed by foreign material.

To be effective and dependable a main line strainer must have low friction loss and must have large capacity to retain foreign material that may be washed into it when the system operates, without plugging the strainer to a sufficient degree to reduce the supply to the spray nozzles below an effective point. Provision must also be made for thoroughly flushing and cleaning the strainer while the system is in operation merely by opening a flushing valve without the necessity for shutting off the protection, removing the cover, and cleaning the strainer basket by hand.

Spray nozzle systems should be flow tested annually, if possible, but in any event the flushing connection should be operated, and a flow equivalent to that required by the spray nozzle system drawn, and the strainer then investigated and cleaned if necessary. Spray nozzles having orifices as small as 1/16 in. in diameter are provided with individual strainers in addition to main line strainers.

Conclusion.

Water spray nozzles have gained a permanent footing in the fire protection field. Portable spray nozzles are now considered standard first-aid fire fighting equipment in the small sizes and in the larger sizes are equivalent to

large hose streams where spray protection is preferable to the use of straight streams. Permanently piped installations of spray nozzles have already received wide usage for special protection of particular hazards as previously discussed. For occupancies within buildings of combustible construction, however, they are supplementary to standard automatic sprinkler protection. At present, because of the relatively small orifices and consequently greater likelihood of plugging, even though strainers are provided, a permanently piped system cannot be considered equivalent in reliability of operation to the automatic sprinkler system and it is not now considered suitable for general overall protection of buildings and contents instead of automatic sprinklers even though the spray nozzle may use water to a better advantage.

It is not likely, however, that spray nozzle protection will remain confined only to the special applications previously discussed. Two of the interesting possibilities of the further use of spray nozzles should be mentioned briefly. These uses are now in the development stages and have not as yet received practical application, but this may be expected within a few years. First, the combination of water spray and carbon dioxide gas has long been considered an ideal method of fire extinguishment and a practical solution may be developed; second, some work has been done with spray nozzles at high pressures from 500 to 600 lbs. per sq. in., but apparently use of this type of equipment would be somewhat limited because of the necessity for employing high pressure pumps or other special means of discharging extinguishing liquid at high pressures.

Records of the National Fire Protection Association have indicated consistently for years that the automatic sprinkler is 96% efficient. Many people would be inclined to believe that good enough. There is no reason, however, why there should not be something better. If a spray nozzle were developed having orifices or passages at least one-half inch in diameter or preferably larger so that it would be no more subject to obstruction than the automatic sprinkler, if it were equipped with individual heat actuated control such as the fusible link, and if it produced a more efficient spray with better distribution and heat absorption capacity than the spray from the automatic sprinkler, there is no reason why such a nozzle could not narrow down the four per cent margin a little closer to perfection. It is quite possible that such a nozzle, whether it is called "spray nozzle" or "improved sprinkler," will be available not too far in the future.

The Normandie Fire.

Fire achieved another victory on the home front in the partial destruction and subsequent capsizing of the *U. S. S. Lafayette,* formerly the French liner *Normandie,* on February 9, 1942. One man lost his life and at least 285 others were injured during the fire. The ship was being converted for service as a troop transport at its berth in New York when the catastrophe occurred. So serious was the loss of the vessel and so loud the hue and cry which swept the entire country that it may safely be said that this fire, more than any other in recent years, served to impress upon the public consciousness the fact that fire is our most important domestic enemy and the most successful Axis partner.

Immediately following the fire and continuing for some three months, several official investigations of the loss were conducted. Other than prepared press releases extracted from the reports of some of these investigations, the full story of the fire has not been exposed to public view. In addition to the usual Court of Inquiry conducted by the Navy Department, the loss of the *Normandie* was probed by the New York City Fire Marshal and by special committees of the Senate and House of Representatives. Of these the House of Representatives report is the only one that has been made available to the N.F.P.A. Department of Fire Record despite persistent efforts to obtain a complete file. Supplementing this report, however, are the many extracts of the Navy and Senate reports which were released to the press. The report of the Fire Marshal of New York City remains shrouded in secrecy.

Fire Protection of the Ship.

"The *Normandie* was not a 'fireproof' vessel, nor is it likely that she was ever considered such, although she was constructed under specifications aimed to make her as 'fireproof' as was deemed by her builders at the time practicable and commensurate with the requirements of a luxury passenger vessel."[1]

While it is true that the *Normandie* was not a "fireproof" vessel, she was so advertised to the traveling public and often referred to as such in the press. Although she exceeded the fire safety requirements of the 1929 International Conference for Safety of Life at Sea (London), she was not built in accordance with the standards for fire-resistive ship construction prepared by the N.F.P.A. Marine Committee and tentatively adopted by the N.F.P.A. in 1933. Thus the construction of the *Normandie* not only fell short of the safety standards available in 1933, two years before she was completed, but also was far below the standards promulgated in 1937 as U. S. Senate Report 184 following fire tests on the *S.S. Nantasket.* It is to be noted of course that the *Normandie* was completed prior to the *Nantasket* tests, which were conducted by the U. S. Department of Commerce and the U. S. Shipping Board, with the coöperation of the

1. Report of the Subcommittee of the Committee on Naval Affairs on the Fire and Capsizing of the *U. S. S. Lafayette.* House of Representatives.

N.F.P.A. Marine Section. These tests proved both the 1929 and the 1933 standards to be inadequate.

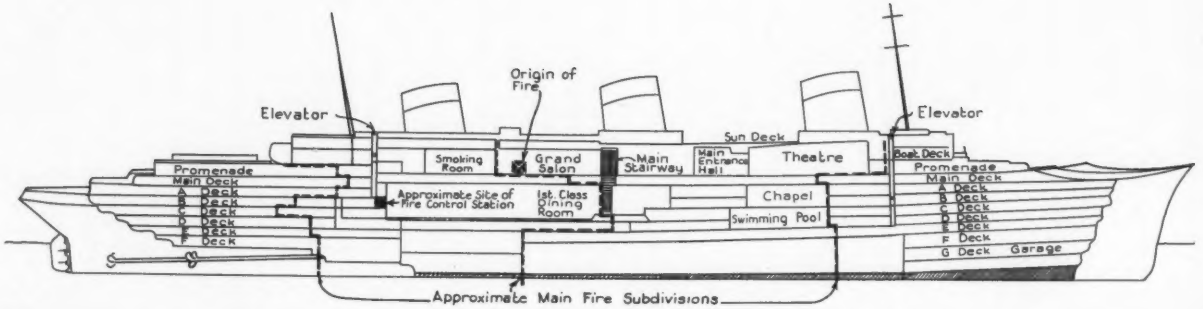
The *Normandie* was divided into four main fire sections by means of three insulated watertight bulkheads which extended from the keel to a point about eight feet above the water line and by so-called "fireproof" bulkheads which extended from that point more or less vertically upwards to the promenade deck. The various decks and bulkheads further divided the ship into approximately 36 subsections which were subdivided into 126 elementary fire sections.

The vessel was equipped with a fire detection system with more than 1000 automatic electric detectors fitted in the cabins. These detectors revealed fire by a lamp in the alleyway adjoining the cabin and also by a light on the main fire control board. The focal point of the ship's fire protection systems was a central fire control station on B deck at which a watch was maintained and from which a fire patrol was supervised. Under French Line management a fire brigade was always available from members of the patrol not on patrol duty. The presence of fire, detected by a member of the fire detail, could be reported to the central control station by telephone or by a manual alarm signal which sounded in the main fire station and in the quarters occupied by the officers and men of the fire brigade. There were 224 fire alarm stations, one in each elementary fire section, which represented a group of about six cabins, and in addition a Klaxon general fire alarm operable from the bridge could be heard throughout the ship. In the holds, storerooms and other more or less inaccessible spaces, visible and audible smoke indicators were installed. The fire extinguishing equipment included three sets of pumps each having a capacity of approximately 1100 gallons per minute at approximately 142 pounds per square inch pressure. The fire mains supplied 504 outlets, most of which were mounted in 211 fire-lockers. These lockers contained double outlets and hose. In the passenger accommodation, manholes were provided in the ceilings of the cabins to facilitate the use of distributor nozzles. A carbon dioxide system was provided for extinguishing fires in the hold, with a supply of nearly 5000 pounds of CO_2. Several foam generators and a large number of portable fire extinguishers completed the fire protection equipment.

As a further precaution when the *Normandie* was in New York, the French Line arranged for alarm service from the American District Telegraph Co. The alarm box, which was installed on the bridge, provided contact with the New York Fire Department through a central station. This service was suspended by the French Line one month after the government took possession of the vessel, and was not resumed.

The U. S. Government Takes Possession.

On May 15, 1941 the Coast Guard ordered a detail of about 150 men on the vessel and Pier 88 to insure her safety and guard against sabotage. This detail was increased after the government took possession of the vessel on



The *Normandie* was the French contender for the title of "the world's largest, fastest and finest ship." She was built at St. Nazaire and was completed in 1935, four years after the laying of the keel. She was a quadruple-screw turbo-electric vessel 1029 feet in length, of nearly 80,000 gross tons, with a power capacity of 160,000 h.p. and capable of a speed of over thirty knots. Her normal cargo capacity was 11,800 deadweight tons. There were eleven decks, including a sun deck, boat deck, promenade deck, main deck and seven decks lettered from A to G. The ship had accommodations for 1972 passengers and the normal complement of ship's personnel numbered 1345 officers and men.

This diagrammatic sketch indicates the approximate locations of the main vertical fire bulkheads, fire control station, and other areas referred to in the report. The sketch is not to scale and is not represented as being an accurate plan of the vessel.

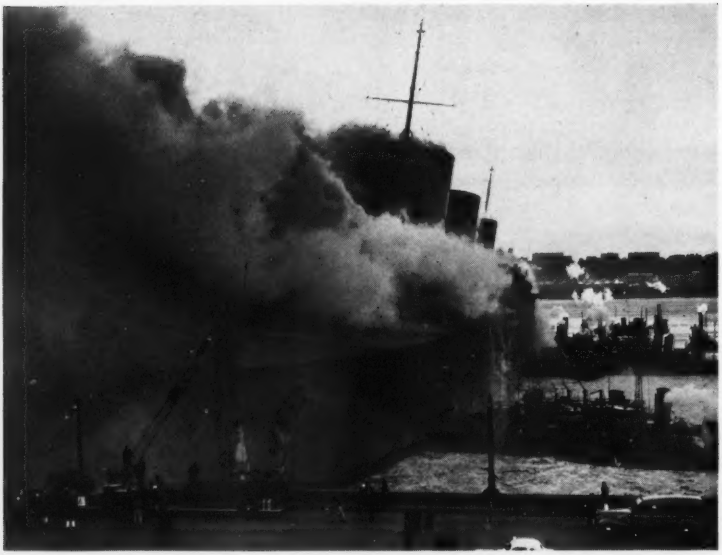
December 12 until there were 6 officers and 275 coast guardsmen assigned to the ship. The Coast Guard fire detail consisted of four petty officers and 36 men assigned exclusively to fire protection. They were divided into 4 watches of nine men each and operated on a plan which was similar to that formerly followed by the French crew. At the time of the fire on February 9, there were nine members of the fire detail on watch, but of the other 27 members off watch, approximately eight had been granted liberty or were absent for some other reason. It was customary for the members of the fire detail to hold drills as frequently as every other day. The remaining two hundred and forty-odd members of the Coast Guard crew did not participate in these drills, however, nor did they have any fire stations or standing orders in the event of fire.

During January, a survey of the ship's fire fighting equipment was made by a large fire equipment concern. This survey revealed that only 10 of the 666 extinguishers on the vessel were built according to American designs and for which replacement parts were available. The report stated that while only three or four of the extinguishers had been tested, it was estimated that only about 50 per cent were in good condition. The report recommended that all of the French-type extinguishers be replaced with American equipment, but this suggestion was never acted upon. The company was ordered, however, to replace the French-type hose connections on the vessel with American-type fittings. Care was exercised to assure that during the change-over hose couplings would always correspond to standpipe outlets, but due to the incomplete stage of the work on February 9, many of the hoses and outlets were still equipped with French couplings.

The principal activity being carried on aboard the *Normandie* was the conversion of the vessel for use as a troop transport. This was being done under contract by Robins Dry Dock & Repair Co., a subsidiary corporation of Todd Shipyards, Inc. The contract under which the conversion was being done was the standard Navy contract, certain provisions of which are of interest because of their relation to the fire. Article 11(a) of the contract provided:

"The contractor shall exercise the highest possible degree of care to protect the vessel from fires. To this end the contractor shall maintain an adequate system of inspection over the activities of welders, burners, riveters, painters, plumbers, and similar workers, particularly where such activities are undertaken in the vicinity of the vessel's magazines, fuel-oil tanks, or storerooms containing inflammable material. * * * At least four 2½-inch diameter hose lines shall be maintained between the vessel and the shore (two forward and two aft), ready for immediate use at all times, while the vessel is berthed alongside the contractor's pier, or in the drydock or on the marine railway* * *. The contractor shall maintain a fire watch on the vessel at all times satisfactory to the naval inspector."

While the financial loss suffered by the damage to the *Normandie* is certainly not the most important item involved, it is none the less interesting to



International.

At a comparatively early stage, dense clouds of smoke from the fire which originated amidships, have enveloped the vessel. Fire department aerial ladders operating from the West Side Elevated Highway and the ground level below provided means of escape for many crew members and workmen. A large armada of fireboats is also in evidence.

observe that Article 12 of the contract limited the contractor's liability for "any and all damage of whatsoever nature—that results from his fault or negligence" to an amount not to exceed $300,000. It also provided that the amount would "be determined by the Chief of the Bureau of Ships after negotiations with the contractor, provided the amount is adequate in the judgment of the Bureau of Ships to protect the interests of the Government."

"No adjustment was made by the Bureau of Ships to increase the limitation of the contractor's liability from $300,000, even though the conversion work involved an estimated expenditure of nearly $4,000,000 on a vessel said to be valued at approximately $53,000,000. The explanation of the Chief of Bureau of Ships for this is that the cost of a contractor's insurance would, in any event, be absorbed by the Government under the contract, and that it was in keeping with the Navy Department's practice of 'self-insurance' not to require the limitation amount to be raised."[2]

Todd Shipyards, Inc., the parent company of Robins and other shipyard corporations, had in its employ as fire superintendent, a former fire chief and fire commissioner of New York City. He made no survey of the *Normandie* and considered that his responsibilities were limited by the shipyard gates,

2. *Op. cit.*

despite the fact that under the terms of the contract Pier 88 was considered as an extension of the shipyard.

The contractor connected four 2½-inch hose lines from hydrants on Pier 88 to standpipes on the forward and after starboard side of the ship, and detailed a group of about 50 unskilled men to act as fire watchers. According to the Todd Shipyards' fire superintendent, these men could learn their job "in ten minutes." The Navy opinion reflected by the findings of the Court of Inquiry after the fire is:

> "The training of fire watchers by the Robins Dry Dock and Repair Company, Inc., was superficial, which training could not possibly qualify the fire watcher to carry out the necessary precautions to prevent, combat or extinguish fires."

The duties of the fire watchers were to stand by burning and welding operations and one member of the fire watch was supposed to be on hand at each burning and welding job.

It is reported that on the day of the fire there were about 80 burning or welding jobs to be undertaken in various parts of the ship. One might reasonably suppose that in view of the fact that there had already been several small fires occasioned by welding and burning operations—four within a week of February 9—the necessity of greater care and more competent organization and supervision would have been obvious to an even moderately intelligent person.

There were approximately 111 burners and welders, some of whom were working in groups or in close proximity to one another. In such cases only one fire watcher was assigned to stand by the entire group. The equipment of these fire watchers consisted of one or more 3-gallon water pails and in cases where the operations were being carried on close to flammable materials "they were supposed to be equipped with circular metal shields and asbestos sheets and to have such other fire-fighting equipment as might be adequate in the circumstances."[3] What was adequate was left to the discretion of the fire watch who, it should be recalled, were expected to learn their job "in ten minutes."

Events Leading Up to the Fire.

During the first three days of February approximately 1140 bales of life preservers were delivered to the ship and were stored temporarily in the main salon on the promenade deck. Each of the bales contained ten life preservers which were made of kapok, a highly flammable cotton-like fiber. The bales were wrapped in a moisture-proof paper and an outer covering of burlap. The officer in command of the Coast Guard detail on board realized that the life preservers constituted a fire hazard and instructed his men to watch carefully that no smoking was done in the vicinity. He was also assured either by the naval inspector in charge of the conversion or by a representative of the con-

3. *Op. cit.*

tractor that no welding or burning operations were contemplated on the salon.

The main salon was a room approximately 100 feet long, 85 feet wide, and 35 feet high, located amidships on the promenade deck. It extended upward to the sun deck or top deck. There were no fire hose or extinguishers in the salon proper, but both were available in lockers close at hand on either side of the deck. The first-aid fire equipment on the promenade deck consisted of forty-one 2½-gallon soda-acid extinguishers, fourteen 12-pound French-type carbon dioxide extinguishers, two 25-pound French-type carbon dioxide extinguishers, and eight 15-pound American-type carbon dioxide extinguishers.

The main salon was provided at its forward and after ends with fire doors which were supposed to prevent the spread of fire to the smoking lounge aft and to the gallery and grand hallway forward. Both are believed to have been manually operated rolling steel shutters. One of these doors was shut and is said to have held the fire, but the other door was left partly open.

About two days before the fire, the naval inspector decided, at the suggestion of the prospective commanding officer of the ship, that since the main salon was to be used as a recreation room for troops, the carpet therein should be replaced with battleship linoleum and that for purposes of safety to the troops and utility, four large metal stanchions designed as indirect lighting fixtures, should be cut off at a height of twenty inches to form seats or tables. The officer in command of the Coast Guard detail was not advised of this decision.

On the morning of February 9, in accordance with instructions of the naval inspector, a force of workmen was assigned by the contractor's representative in charge to cut off the four stanchions by means of oxy-acetylene torches. The force assigned to the job consisted of a burner, two fire watchers and a subforeman in charge of eight unskilled laborers whose duty it was to control the stanchions while being cut and lower them carefully to the deck. The equipment of this group consisted of the burner's torch and oxygen and acetylene tanks, two 3-gallon pails of water, an asbestos board about 2 ft. by 3 ft. and a semicircular metal shield approximately 36 inches high. The evidence is conflicting as to whether there was any fire hose laid out at the time, although there is some credible testimony that a 1½-inch hose, part of the ship's equipment, had previously been and remained laid out from the port promenade and extended into the salon, but that this hose was not connected to the standpipe or fire main.

Because of the activities of the linoleum workers the bales of life preservers, which originally had been stored in the center of the salon, had been moved to the port side and piled semicircularly around the forward and after stanchions and between those stanchions and the side wall of the salon. There was an aisle through the piled bales leading to the open door on the port side of the salon.

International.

Another view of the blazing "Normandie" during the height of the fire. Note fire fighters on the roof of Pier 88, formerly occupied by the French Line.

During the morning the two stanchions on the starboard side were burned off without incident. Shortly after 2:00 P.M. the workmen returned to the salon to remove the two remaining stanchions on the port side. There were but seven men in the gang of unskilled laborers at this time because one of the workmen failed to report for work and no fire watchers were present.

Before starting to burn the port stanchions, a number of the bales of life preservers were moved and piled on others to make a space large enough to walk around. The piles were placed at distances variously reported at from 3 to 8 feet from the stanchions. The third stanchion was cut off without incident, and the workmen proceeded to the fourth and last stanchion on the port side aft. In the absence of any regular fire watchers, one of the members of the unskilled gang held the asbestos board above the metal shield to prevent sparks from flying toward the bales. When the stanchion was cut nearly through it was to be lowered to a horizontal position and the final brief cutting operation performed. To assist in lowering the stanchion the man holding the asbestos shield set it aside and climbed up on the bales to handle a guide rope. Because of the height of the metal shield, that too was removed. The stanchion was lowered to horizontal for the burner to start the final "snip off" operation. The job was so nearly finished that the man in charge of the burners and welders started to leave for another job. Likewise the subforeman in charge of the laborers had started to walk away. The last burning operation of freeing the stanchion was thus being performed without benefit of the asbestos board or the

metal shield, without a fire watch or even the observance of the foreman. It was during the final seconds of the job that a small flame was observed darting upward from one or two of the bales nearest the point of the burner's operation.

Story of the Fire.

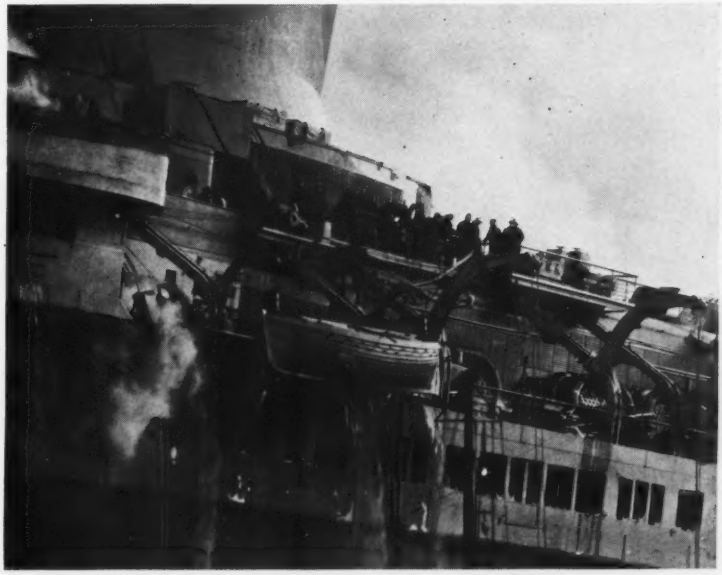
The story of the early stages of the fire has the elements of a Hollywood slapstick comedy. Unable to beat out the flames with their hands, the workmen began throwing the blazing bales hither and yon toward the center of the salon. In the excitement someone tripped over a bucket of water and spilled all or nearly all of it on the deck. The hose from the port promenade previously mentioned, was connected and played on the fire, but other workmen rushing in from the starboard promenade with another hose were dismayed when only about a bucketful of water came out of it. Reports indicate that the hose was badly kinked. A workman brought in a fire extinguisher, but threw it down in disgust after it failed to function; whether from his ignorance of its operation or from some other cause is not clear.

The Coast Guard seaman on duty in the central fire control station learned of the fire from a member of the Coast Guard fire detail who reported it orally. The man in the fire control station attempted unsuccessfully to reach his superior officer by telephone. He then called the fire brigade, notified the distribution room to shut off the ventilators, and called the bridge, instructing the coast guardsman on duty there to sound the general fire alarm. The man on the bridge reported that he couldn't find the switch.

There were two fire alarm switches on the bridge, but these had been disconnected for several days prior to the fire by a contractor, apparently without the knowledge of any of the Coast Guard personnel. When the Coast Guard security officer learned of the fire, he ran to the bridge and threw these two switches, expecting the alarm to sound all over the ship, but nothing happened.

Some delay was occasioned in the response of the Coast Guard fire brigade because the brigade was quartered temporarily in a room on A deck, which was without telephone communication to or from the central fire control station. It was necessary for a member of the brigade to stand by in the regular quarters on the main deck and transmit messages in person to members of the brigade on the deck below.

The Coast Guard assistant security officer heard the report of the fire over the ship's loud speaker system. He rushed to the main salon and found it in flames. He saw no hose in use at the time, but found some on the deck and tried to connect it to one of the valves. This was not possible because there was an American-type fitting on the hose and a French-type fitting on the valve. He then proceeded to the temporary quarters of the fire brigade and took charge of about 15 men he found there. They went to the main fire locker on the main deck where he relieved the security officer who was distributing extinguishers to the workmen. The latter rushed to the gangway and called to a



Acme.

Fire fighters working on the ship had practically extinguished the fire before they were obliged to abandon the vessel because of an increasing list. Quantities of water are to be seen sluicing from the boat deck.

policeman on the dock to turn in the city fire alarm. The assistant security officer meanwhile proceeded with his men to the scene of the fire.

At about this time, at least two other officers ordered the city fire alarm on the pier to be sounded by different persons. Who actually sounded the alarm that was received by the Fire Department is neither clear nor particularly significant.

By this time the smoke was very thick in the salon and fire fighting was further hampered by the fact that the ship's lights had been turned off in this section as a safeguard against short circuits. Certain members of the fire brigade who had gas masks and one or two who had asbestos suits attempted unsuccessfully to reach the seat of the fire. It is reported that their gas masks were ineffective.

Meanwhile the only fatality occurred when a workman fell from the sun deck to the boat deck. According to a fellow-workman who was with the victim at the time, he was thrown from a ladder by the concussion which resulted when the burner's tank of acetylene exploded from the heat of the fire in the salon.

The following paragraphs, quoted from the House Investigating Committee report, convey an impression of the bedlam on board the *Normandie.*

"It is difficult to imagine a more confused state of affairs than that which existed on the *Normandie* at and during the course of the fire. Five hundred men of the prospective crew, unfamiliar, for the most part, with the ship and with no previously assigned stations, duties, or responsibilities, were under the command of the prospective commanding officer.

"Two hundred and eighty-one Coast Guard officers and men, many of them raw recruits, and of whom less than 40 had specific assignments and duties in the event of fire, were under the command of the Coast Guard lieutenant commander.

"One thousand seven hundred and fifty employees of Robins, of whom 50 were untrained men designated as 'fire watchers,' were under the supervision of the vice president of Robins and the assistant superintendent in charge of operations.

"Six hundred and seventy-five employees of some thirty subcontractors were under the direction of their respective foremen or superintendents.

"In addition, there was the naval inspector, a lieutenant commander in the Naval Reserve, with nine civilian assistants, all apparently concerned primarily with allocating specific job orders to the contractors and subcontractors.

"The naval inspector was the only naval authority on board the vessel with jurisdiction over the contractors and that, primarily was in a supervisory capacity. He had no jurisdiction over the Coast Guard or prospective naval personnel nor did the officers in command of the latter units have any jurisdiction over him or any units other than their own.

"Shortly after 3 P.M. the commandant, the district materiel officer, the prospective commanding officer and the captain of the port, a Coast Guard officer, senior to the lieutenant commander in charge of the Coast Guard unit on the vessel, arrived at the scene of the fire. Fire-fighting equipment of the city fire department had already arrived and the firemen were in action. Other officials were assembled at the pier, including the collector of customs, the mayor of New York, the fire commissioner, the fire marshal, and the police commissioner. All made various sorties and tours of inspection on and about the ship and pier. A central office was established on the pier, in the offices of the French Line, where conferences were held from time to time. French Line officials were consulted, including the former master of the *Normandie*. A salvage expert from Merritt, Chapman & Scott Wrecking Co. was called in.

"The commandant did not consider himself either in charge of the situation or to be the responsible naval officer present. He had considered the *Normandie* to be under the jurisdiction of the Bureau of Ships and of the district materiel officer. He was unfamiliar with the *Normandie*, and prior to the fire had never been on board her nor received nor gave any orders with respect to her, other than of an advisory nature with respect to maintaining an adequate Coast Guard personnel aboard. Accordingly, he did not feel qualified to assume command and acted only in an advisory capacity. Orders were given, however, from time to time in his name and other naval and Coast Guard officers were under the impression that he had assumed the responsibility and command by virtue of his rank and presence. He considered the fire department to be in charge of the fire.

"At the fire, the district materiel officer, an experienced technician and marine engineer, considered himself also to be acting in an advisory capacity,

International.

Section of the main salon where the fire originated. View shows that the fire was extinguished in the area before the ship began to list appreciably. Note the large roll of linoleum which was being laid when the fire started.

and issued orders only to members of his staff. The naval inspector received no orders from any source, although he stood by in the conference room from time to time.

"The lieutenant commander in charge of the Coast Guard unit looked to orders from the captain of the port. The captain of the port considered the commandant in command."

During the fire the pressure in the water mains was stepped up from a normal pressure of 60 or 70 pounds to 100 pounds. Because of the downdrafts through the ventilators, boiler uptakes and other apertures, smoke from the fire soon reached the engine room and forced the Coast Guard engineers to close down the fires and abandon the engine room at about 2:55 or 3:00 P.M. Sufficient steam pressure remained to operate the generators and pumps until 3:15 P.M.

The first alarm received by the New York Fire Department was at 2:49 P.M. from a private alarm box operating through a central station and located in the center of Pier 88. Estimates place the start of the fire at between 2:35 and 2:40, thus indicating a delay of about 10 to 15 minutes between the start of fire and the first alarm received by the fire department. Ninety seconds after the receipt of this alarm, the first fire apparatus arrived at the scene. The

International.

During the morning after the fire, while an aroused public protested the conditions which permitted this disaster, a lone fireboat continued to pump water on the prostrate "Normandie."

International.

The main stairway located just forward of the main salon. A rolling steel fire door at the head of the stairs is partially closed. The intense heat has destroyed the hanging ceiling and all combustibles.

first alarm response consisted of four engine companies, two ladder companies, a fireboat and a salvage company. A second alarm was sounded at 3:01 P.M. and other alarms followed at 3:02, 3:12, and 4:08 P.M.

While no official information about fire fighting operations of the New York Fire Department is available, it is known that following the fifth alarm there were twenty-four pumpers, six ladder trucks and three fireboats on the scene, not to mention other miscellaneous equipment and an unstated number of privately owned towboats. The three fireboats alone, which arrived at 2:55, 3:13, and 3:27 P.M. respectively, poured an estimated total of 839,420 gallons of water into the *Normandie's* superstructure over a period of four hours. In addition an undeterminable quantity was poured into the ship from shore apparatus and privately owned towboats. Although much of this water rolled over the sides, a large quantity backed up along the upper decks and into the staterooms. By as early as 3:30 P.M., or less than 45 minutes after the arrival of the first apparatus, the *Normandie* had taken a notable list to port and as more and more water was pumped into her superstructure, the list gradually increased. The fire was reported under control at about 6:30 P.M. and most of the fire department apparatus and personnel returned to quarters. The actual

fire damage has been reported as "relatively slight," although it is understood that three decks were gutted.

The Capsizing.

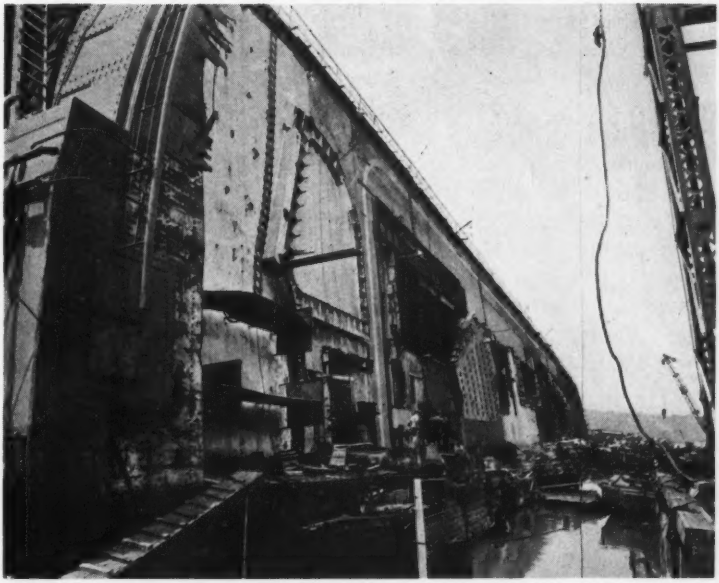
By the time the fire was brought under control the *Normandie* had taken on a list to port of 10 degrees. The danger of capsizing was then fully realized by the naval authorities whose problem it was to prevent this catastrophe, if possible. The feasibility of scuttling the ship was discussed, but there appears to have been some indecision as to what was the best course to follow. An attempt was made to scuttle her by removing the plates from the condensers in the engine room (the ship had no sea cocks), but smoke prevented the men from accomplishing their mission. The decision to scuttle was then abandoned. It was decided that scuttling would probably not prevent the ship's capsizing anyway because of the list, the fact that the bottom of the ship sloped to deeper water on the far side (the regular berth of the British liner, *Queen Mary*), and the fact that the *Normandie* had no longitudinal bulkheads to prevent "free water" from settling on her port side. The decision not to scuttle the ship was also influenced by the opinion of the fire chief that scuttling might cause the fire to spread to the pier and along the waterfront by reason of burning oil. Efforts were made to fill the starboard double-bottom tanks by means of holes cut from the outside. Due to the difficulty of locating the tanks, however, only four of the seven tanks were thus cut open. The effect of partially filling these tanks was to lessen the list a few degrees for a short time.

The fire department attempted to pump water from the spaces on the promenade and A decks, but the pumps were not designed for the purpose and were ineffective. Adequate pumps are reported to have been unobtainable. By 9:30 P.M. the list of the *Normandie* had increased approximately 15 to 17 degrees, after which she took no further appreciable list for several hours. As the incoming tide raised her from the bottom of the slip, however, her list increased. At midnight the list had reached 35 degrees. A half hour later the ship was ordered abandoned and at 2:45 A.M. she capsized.

The Aftermath.

Before the fire-scarred hulk had settled in the mud, charges and countercharges of sabotage, negligence, carelessness and bureaucratic stupidity were hurled right and left. The New York newspaper *"P.M."* alleged that sabotage on the *Normandie* would have been a simple matter and revealed that one of its own reporters had had no difficulty in obtaining work on the ship without any personal investigation. This is substantiated by the findings of the House investigating committee to the effect that,

"Opportunities for sabotage, or almost any subversive activity were, however, abundant on the *Normandie*. There was no adequate check made of the employees of the contractor or subcontractor and especially of alien employees. It was possible for individuals to board the ship without any credentials or



Acme.

A recent view, showing the extent of salvage operations. Funnels and superstructure have been removed preparatory to attempts to right the hulk.

identification other than a numbered badge, indicating the name of the contractor or subcontractor by whom they were supposed to be employed. No investigation had been made as to the manner of the selection of subcontractors' employees, and apparently no responsibility was fixed upon the employers with respect to selection of their personnel. That the fire may not be attributed to sabotage is only indicative, therefore, of the fact that saboteurs, if there were any, did not deem the time ripe for sabotage."

The findings of every group that investigated the loss emphasize that there was no evidence of sabotage whatsoever. While they are in agreement on this, other conclusions are not uniform. In general the House investigating committee blamed "carelessness and lack of supervision"; the Senate investigating committee blamed the Navy Bureau of Ships; and the Navy Court of Inquiry blamed the Robins Dry Dock and Repair Co. In the words of the House committee, "It is not difficult to find acts of carelessness or omission on the part of many individuals connected with the *Normandie,* but it is difficult to place the sole responsibility upon any one individual."

It was revealed that there was undue haste, indecision and lack of forethought in connection with the conversion of the ship. She was taken over without any clear idea of what use was to be made of her or by whom. When it was finally decided to make a troop transport out of her, contradictory orders

were issued as to the date the work must be completed. While there can be no doubt that unreasonable pressure was placed upon those in charge of the conversion to finish the work, this fact does not mitigate the responsibility upon them to protect Government property, which in this case was an important naval auxiliary.

The monetary loss occasioned by the fire and capsizing cannot be determined until the success or failure of the salvage operations now being conducted is established. The vessel cost approximately $53,000,000 when she was built during the depths of the "depression." The Navy has voiced confidence in its ability to salvage the ship and as the QUARTERLY goes to press the superstructure has been removed and work is going forward preparatory to righting the hull. The marine salvage company engaged in righting the vessel is said to hold a $5,000,000 contract from the Navy for the work involved.

Since the vessel capsized, at least two more fires have occurred on board. Details of the first of these, which took place on March 13, are meagre. It was variously reported in the press as having been due to the use of a welding torch and to spontaneous ignition of some rubbish on D deck. This fire was extinguished by a salvage worker with a hose line.

On April 18 a more serious fire occurred in an after hold. It was started by an acetylene torch which ignited cork insulation lining certain refrigeration compartments. Three alarms were sounded for this fire, which burned from 6:00 P.M. until 10:00 P.M. Great difficulty was experienced by the firemen in reaching the seat of the fire and they were obliged to cut some 15 holes in the hull plates in order to reach the flames with distributor nozzles and cellar pipes. During the fire one of the firemen was injured when he fell sixty feet through what normally would have been a companionway. His fall was broken by striking two other firemen; otherwise it is probable that he would have been killed.

The subsequent fires raise some question as to whether conditions revealed by the investigations of the first major fire have been fully corrected.

Kewanee Conflagration.

A watchman, sweeping the second floor of the large unsprinklered three-story brick-joisted building of the Kewanee Dry Goods Company, smelled smoke about 1:37 A.M. on the morning of April 13, 1942. He telephoned to the fire department but found that a more observant janitor of an adjacent building, and a policeman, had already given the alarm. When the five permanent firemen on duty arrived with the pumper, flames were shooting through the windows above the loading platform at the rear of the building. The fire also quickly spread up the open elevator and stair shafts from the basement to the third floor. A high wind was blowing and in about twenty minutes windows across the street in front of the building were breaking. Before the fire was brought under control a total of seventeen business buildings had been destroyed and ten others were damaged. The insurance loss exceeded $1,650,000 on property valued at $2,568,750. No information is available as to the amount of the uninsured loss.

This conflagration swept through portions of two blocks mainly consisting of two- and three-story brick-joisted business buildings. The largest structure involved was the dry goods store in which the fire originated. This building was 84 feet wide and had a depth of 150 feet. None of the buildings destroyed had the protection of automatic sprinklers. Protection against exposure fires was also lacking in the destroyed buildings.

Story of the Fire.

The Kewanee Fire Department responded promptly to the first alarm with a 750-gallon per minute pumper. It is reported that the apparatus was getting under way when the call was received from the dry goods store watchman. However, upon arrival, it was found that the fire had gained great headway and was in substantial control of the dry goods store. As soon as the apparatus had been dispatched the telephone operator called the fire chief and the five off-shift firemen. The off-shift men responded with a 500-gallon per minute combination pumper-ladder truck.

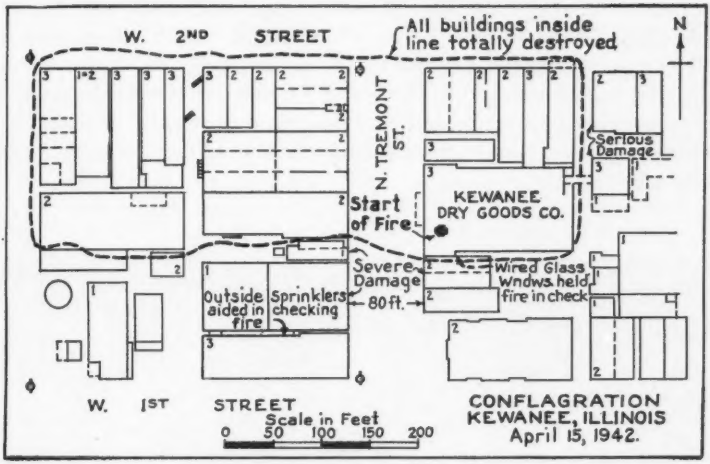
The first pumper upon arrival was connected to a hydrant at the corner of North Tremont and West Second Streets. Two 2½-inch hand lines were run to the front of the dry goods store. When the pumper-ladder truck arrived connection was made to a hydrant at the corner of West First and North Tremont Streets and a pumper line was run to the front of the store. In addition a line from another hydrant was taken to the rear of the fire area.

At approximately 2 A.M., or about the time that the off-shift firemen arrived, the fire was spreading across North Tremont Street. The Kewanee Fire Department lacked the heavy stream appliances needed to fight large

Note: This account is based upon reports and information furnished by the Illinois Inspection Bureau (Member N.F.P.A.), Illinois State Fire Marshal John H. Craig (Member N.F.P.A.), from fire departments assisting at the fire, and from other sources.

Wide World.

View of the devastation wrought by a $1,500,000 conflagration that swept through a portion of the business district of Kewanee, Illinois, early on the morning of April 13, 1942. The blaze, beyond control when the first firemen arrived, was checked through the aid of eight outside departments after seventeen buildings had been destroyed and ten other structures were damaged.



fires, and the heat became so intense that it became necessary to move the 750-gallon pumper one-half block to the north. In this operation 250 feet of hose was lost.

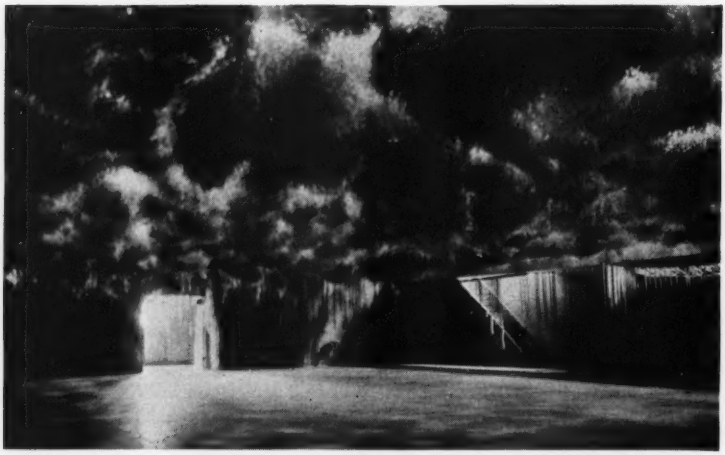
The fire chief, realizing that the fire was out of control, began early to call assistance from departments within a 50-mile radius. Eight outside departments answered the call. The first outside help was on the job by 2:20 A.M. In addition, the 500-gallon pumper and ten man part-paid crew of the Kewanee Rural Fire Protection District remained in the fire station to cover the city and answered one call during the conflagration. As the outside equipment arrived it was placed in service around the fire zone and some fourteen pumper and six hydrant streams were supplied. At least two deluge sets were placed in effective operation by the outside departments.

Exposure Protection.

One building and a part of another building located to the south of the fire area were equipped with automatic sprinklers. No inside sprinkler heads were fused. However, manually operated outside sprinklers on the roof and walls of one of the sprinklered buildings, a three-story newspaper plant, were turned on at 1:45 A.M. and were operated until 4 A.M. Spray from these sprinklers carried by the wind helped materially to protect a more seriously exposed furniture store building to the north.

Window openings in the north wall of a two-story building immediately adjoining the building where the fire started were protected by wired glass windows in metal frames. This protection helped protect the contents of this building from total destruction, although unfortunately the flames entered unprotected windows at the rear of the building and caused serious damage.

Records of the Water Department indicate that water supplies were ample at all times and water pressure of about 60 pounds was maintained. Additional water supplies available through cross-connections with industrial plant facilities were not required. Water consumption during the peak demand was estimated at approximately 2800 gallons per minute. This included wastage from connections in the ruins and the usual domestic demand in addition to the fire flow.



Decoration for Tragedy.

M. K. Rouse of the Board of Fire Underwriters of the Pacific (Member N.F.P.A.) contributes this picture of ceiling decorations of a dance hall. He writes:

I understand that this type of decoration has been more or less favored in small communities in the West where they desire unusual effect at low cost, and I believe I can assure you they won't do it very often without unusual effects. The picture shows the dance floor of a small school gymnasium. The building is new, about 65 by 100 ft. and has a 60 by 80 ft. hall. There is a small balcony in the building, and between the balcony and the opposite wall, covering an area of about 50 by 70 ft. were hung the decorations. The decorations, consisting of a mat averaging between 3 and 4 ft. thick of tumble weeds (you probably know that dry tumble weeds burn with extreme speed), were hung about 9 to 10 ft. above the floor and colored lights were played upon the mat. At the dance the hall was packed. It is understood that approximately 150 couples attended and it is a wonder to me that a major disaster did not occur. I have been given to understand that this type of decoration is exceedingly effective and the initial cost is very low. Just what the final cost might be I leave to your judgment.

Burlap and Cotton Sugar Bags.

The extreme combustibility of burlap bags, as compared with ordinary cotton bagging, was convincingly demonstrated by a fire at the plant of the Fair Play Caramels, Inc., Johnson City, New York, on May 9, 1942. The fire started at 4:10 P.M. on a Saturday afternoon while a contractor's employee was using a portable cutting and welding torch to install air conditioning equipment. The work was being carried on only fifteen feet from an area containing four thousand 100-pound bags of sugar. About half of the sugar was in burlap bags and the balance was in cotton bags.

The usual precautions of moving combustible stock a safe distance or protecting the stock with asbestos curtains were not observed. Neither was a watchman with fire equipment posted near the cutting operations. A welding spark landed among the bagged sugar and started a fire which flashed quickly over a portion of the sugar pile which was in burlap bags. The building watchman, who happened to be near by, used an extinguisher, but the fire was already beyond control and had burrowed deep into the pile. The spread of the fire was checked when it reached the sugar stored in the cotton bags.

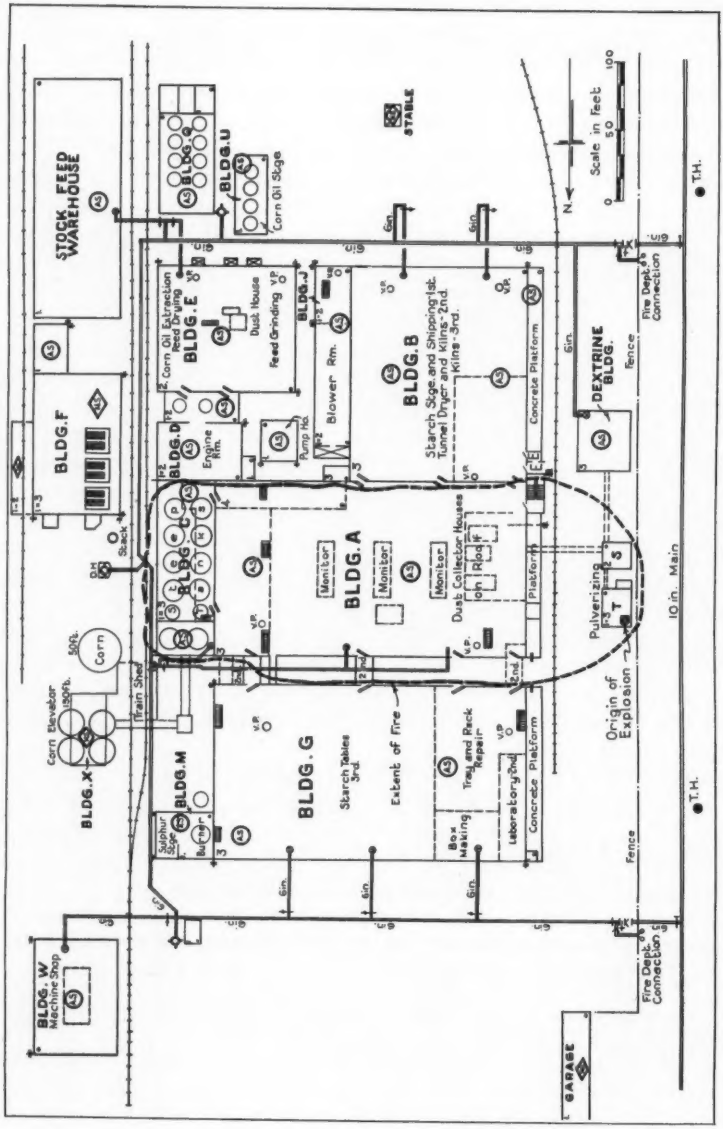
Sufficient heat was generated to open seventeen sprinkler heads. Over the storage area several sections of roof joists and boards were burned, except where directly above sprinklers. This burning was in part due to the slower fusing of three 286° and three 212° sprinkler heads surrounding a unit heater, which allowed the fire to get into the roof.

The fire department responded promptly and used two small hose lines with half-inch nozzles to control the fire among the bags where not reached by water from the sprinklers.

The smouldering fire in the center of the pile of sugar bags made it necessary to remove the bags. A considerable amount of sugar had become syrup and had run through the floor. Thirty-five employees responded promptly and did excellent salvage work in protecting food products on the floor and below, and in cleaning and lubricating candy packaging machines.

Exact loss estimates are not available at this time, but the loss has been estimated at several thousand dollars. Damaged sugar was removed to a refinery for immediate reprocessing.

This report is based upon information furnished by the Inspection Department, Associated Factory Mutual Fire Insurance Companies (Member N.F.P.A.) and Fire Chief William J. Rickert, Johnson City, New York.


STOCK FEED WAREHOUSE
BLDG. F
BLDG. X
Corn Elevator
500 bu.
Corn
Track
Train Shed
BLDG. W
Machine Shop
BLDG. M
Sulphur Stge.
Burner
BLDG. G
Starch Tables 3rd
Extent of Fire
Box Making
Tray and Rack Repair
Laboratory 2nd
Concrete Platform
BLDG. A
Monitor
Monitor
Monitor
Dust Collector Houses
Platform
Pulverizing
Origin of Explosion
BLDG. B
Starch Stge. and Shipping 1st.
Tunnel Dryer and Kilns 2nd.
Kilns 3rd.
Concrete Platform
DEXTRINE BLDG.
Fence
Fire Dept. Connection
10 in. Main
T.H.
T.H.
Fence
Fire Dept. Connection
GARAGE
BLDG. E
Dust House
Feed Grinding
Corn Oil Extraction
BLDG. D
Engine Rm.
Pump No.
Blower Rm.
BLDG. C
BLDG. U
Corn Oil Stge.
STABLE
Scale in Feet
0 50 100
N

Starch Plant Explosion at Indianapolis.

Report by Indiana Inspection Bureau
(Member N.F.P.A.).

An explosion and fire on June 5, 1942, in a medium-sized starch plant resulted in a loss estimated at approximately $700,000. The plant where the fire occurred was the Piel Brothers Division, National Starch Products, Inc., located at Indianapolis, Indiana. It did not meet modern requirements in construction, equipment, dust control, or segregation of processes.* The plant had a daily grinding capacity of 7600 bushels of corn, yielding about 13 tons of starch and 16 tons of feed and corn oil as by-products.

Description of Plant.

The plant was erected about forty years ago. The main buildings are largely of ordinary brick-joisted construction, three stories in height without basements. There are incombustible floors under kilns in Building B. Floor openings are enclosed. Five small although important auxiliary buildings are of fire-resistive construction. Ample explosion vents were provided in the north and west walls of Building T, and in the south and west walls of Building S. (See diagram.)

Hazards pertaining to dry starch processing were not protected in accordance with modern practice.

A single source dry pipe sprinkler system covered about 80 per cent of the total value. Water supply for sprinklers and other fire protection equipment was from city mains with a residual pressure at grade of 62 pounds with 1235 gallons flowing.

Story of the Fire.

While the night shift was on duty, an explosion occurred at 8:45 P.M., said to have originated within a pulverizer located in Building T. This is an unsprinklered building near the front of the plant. This explosion was followed by a second and third explosion within Building A, occupied for dry starch processing on all floors. The explosions were followed by a severe fire that destroyed Building A, the roof of Building C, and damaged equipment in Buildings S and T. There was no damage to the structure of Building T other than to the explosion-venting sash and glass which served the purpose for which it was installed. Six men were injured by the fire and explosions, one critically.

The explosions opened so many sprinkler heads throughout the entire dry starch processing area that the sprinklers were ineffective and were shut off to

*N.F.P.A. Code for the Prevention of Dust Explosions in Starch Factories.

Indianapolis Star Photo.

Flames shown raging in Building A of the National Starch Products, Inc., plant at Indianapolis, Indiana. Fire in this building resulted from a series of explosions occasioned by an explosion in a pulverizer located in Building T, the outline of which may be seen at the extreme right of this picture.

conserve water for the pumpers and for sprinklers in exposed areas not yet involved. The fire department successfully held the fire to the buildings mentioned.

At the time of the explosions 66 men were on duty but none were regularly employed in Building T, where the equipment runs unattended except for periodical inspections. The first explosion was probably caused by some foreign substance, probably a nail, entering the pulverizer. A double handful of nails was removed from the electromagnet box after the explosion. The fire from the explosion was transmitted to the near-by Building S through a screw type conveyor having no choke provided. Damage was comparatively light in this building, as the only loss was to equipment.

An examination of the automatic chokes in the delivery and return screw type starch conveyor from Building A to Building T disclosed no evidence of fire. Both chokes were full of starch.

Several theories were advanced as to the cause of the explosions in Building A, which was separated 55 feet from Building T. However, it is believed that burning portions of a stocking type dust collector in Building T, observed blown into the air by the first explosion, passed through the open windows and doors of Building A. This building was especially vulnerable from the outside

along the west wall, because the starch dumping and bag filling process was located there and there was a considerable amount of free starch in the air at the open windows and doors.

Two explosions are reported to have occurred in Building A, followed by a rapid spread of fire in all floors in which the unsegregated starch handling processes were located. Although the building was under sprinkler protection, the type of construction, which provided many ledges for the accumulation of starch dust, aggravated the spread of fire. A large number of the 450 sprinklers in each floor operated before the arrival of water, rendering the equipment ineffective. There was no evidence of rupturing of the sprinkler piping in the larger pipe sizes.

Fire Fighting Operations.

The first alarm was transmitted from a central station fire alarm box in the plant office to the fire department at 8:45 P.M. Due to the locality a second alarm was automatically sounded at 8:48, and a total of six companies responded. At 9:07 and again at 9:12 additional companies were called. Many off-duty firemen reported. An estimated 100 firemen were present. Ten pumpers responded and five were used to supply sixteen lines of 2½-inch hose and several lines of 1½-inch hose.

Before the arrival of the first company Building A was totally in flames and the window sash in Building G was burning. Firemen were deployed around Buildings A and C, and operated inside of and on the roofs of Buildings B, G and D. Due to the excellent work of the fire department in protecting roofs and openings to Buildings B and G, the fire did not enter these buildings. There was some damage to the roof of Building C.

The water pressure which had automatically been raised 10 pounds on the second alarm was increased further at the request of the fire department. No shortage of water or low pressures were reported.

Extent of Loss and Conclusions.

The loss from the fire amounted to approximately 40 per cent of the plant value and has been estimated at approximately $560,000. A use and occupancy loss of about $137,000 appears likely from preliminary estimates.

But for the flying particles of burning material from the dust collector the fire should have been confined to the smaller Buildings T and S. The fire demonstrates the need for fire-resistive construction, segregation of processes in small areas, and the elimination of surfaces where dust can accumulate. It is expected that Building A will be rebuilt and equipped to conform with modern standards.

Fires in Which There Was Loss of Life.

Second Quarter, 1942.

During the past three months the Department of Fire Record has received reports of sixty fires which involved loss of life.* Two hundred and twenty-three lives were lost in these fires. Six fires caused five or more deaths each, and these are summarized below.

MARCH 28, 1942, BRIDGEPORT, CONN. Seven persons including three women were killed and about seventy-five others injured by an explosion which demolished the packing and shipping building of a munitions plant. The cause of the explosion is not known but it is believed to have occurred while a cover was being nailed on a box of explosive materials. (H-44520.)

MAY 1, 1942, VERSAILLES, PA. Eight women were killed and ten others were injured in an explosion which wrecked the mixing plant of a railway signal manufacturer. The explosion is believed to have occurred when through some accident or carelessness a steel roller weighing about two pounds fell on a tray of percussion discs used in the manufacture of railway torpedoes. (H-44515.)

MAY 12, 1942, OSAGE, W. VA. Fifty-six miners were killed in a coal mine explosion. (H-44516.)

MAY 31, 1942, GREENWOOD, S. C. Five persons, including a family of four, died by suffocation in a fire which destroyed a small frame hotel during the early morning hours. The other six guests in the hotel were rescued by firemen. The cause of the fire was not determined. (H-44514.)

JUNE 3, 1942, STOCKTON, CALIF. An explosion said to have been due to the use of gasoline for cleaning guns, occurred at an Army air station, taking the lives of ten soldiers and one civilian fireman. (H-44522.)

JUNE 5, 1942, ELWOOD, ILL. Fifty-one men were killed and scores injured in an explosion at the huge Elwood Ordnance Plant. The explosion, which occurred in the shipping room of a shell-loading unit, leveled several buildings and broke windows as far distant as twenty-five miles. It is reported that the blast was heard two hundred and fifty miles away. Cause of the explosion is undisclosed. (H-44521.)

Foreign Fire.†

APRIL 28, 1942, TLAPALA, MEXICO. Thirty-two persons were burned to death and more than a score were injured in a fire caused by fireworks during a fiesta. The fireworks ignited thatched dwellings, and barbed wire around the festival enclosure prevented the crowd of several hundred from escaping promptly. (L-6680.)

*This record is made up from reports received between March 20, 1942, and June 15, 1942. A few of the fires included herein occurred prior to March 20, but were not reported until subsequent to that date.

†Not included in the accompanying tables.

Typical Fatal Fires.

Clothing Ignited.

APRIL 24, 1942, NEW YORK, N. Y. A man was burned to death after he fell asleep while smoking in bed. (L-6679.)

APRIL 24, 1942, NEW YORK, N. Y. Burned while playing with a lighted candle, a seven-year-old girl died the following day in a hospital. She and her small brother were playing with the candle and the flame ignited the girl's dress. (L-6676.)

Flammable Liquids and Vapors.

MARCH 14, 1942, BEDFORD CENTER, N. Y. A woman and three of her children were fatally burned when the eldest son tossed gasoline on embers in the fireplace of their home. (L-6677.)

MARCH 16, 1942, BINGHAMTON, N. Y. A young filling station employee was fatally burned by a gasoline explosion. Gasoline vapors became ignited while he was using gasoline to clean the lubrication room of the station. The blast demolished a cinder block wall on one side of the building, but the fire which followed was quickly extinguished by firemen. (H-44519.)

MARCH 27, 1942, PORTLAND, ORE. One man was fatally burned and a warehouse destroyed in a $461,000 fire which originated when a gasoline tank truck and a locomotive collided. The tank truck and trailer, loaded with some 5000 gallons of gasoline, was struck by a switching engine as it was crossing the tracks. The impact ruptured the trailer tank and an explosion occurred. Burning gasoline flowed over the ground and into the basement of a near-by warehouse, and the fire soon spread through unprotected openings to involve the entire building. The locomotive fireman was severely burned and died in the hospital the following day. (H-44524.)

APRIL 28, 1942, PORTLAND, ORE. A man was burned to death and three firemen were injured by a fire which swept through a fire-resistive factory building. The fire started when the janitor, either through carelessness or ignorance of the proper method of firing a manually controlled oil burning furnace, threw a lighted match into a pool of oil in the firebox. The resulting flash ignited his clothing, and in his frantic efforts to extinguish the flames quantities of paper patterns and other combustibles used in making automobile seat covers became ignited. He finally ran out into the street, where he was caught, his burning clothes extinguished, and he was sent to a hospital, where he died. The factory interior was gutted. (H-44523.)

MAY 29, 1942, WASHINGTON, D. C. A man's attempt to evade the gasoline rationing restrictions resulted in the death of a five-year-old boy. The child was sitting on the rear seat of an automobile while the man was pouring gasoline from a drum into the automobile tank. Gasoline vapors were apparently ignited by a gas water heater in the basement of the house which was connected with the garage. Investigation revealed that the man had stored three drums of gasoline in a private garage in violation of District of Columbia regulations prohibiting the storage of flammable liquids without a permit. (H-44517.)

JUNE 5, 1942, SOMERVILLE, MASS. One man died and several others were burned when a hose connection, carrying fuel oil under pressure to a torch,

THE CAUSE

THE RESULT

A man was fatally burned and a $461,000 warehouse fire resulted from a collision between a gasoline tank truck and a locomotive at Portland, Ore., on March 27, 1942.

Causes of Loss of Life, April-June, 1942.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

Cause of Fatality	Men	Women	Children	Total
Aircraft Fires	1	0	0	1
Asphyxiation (Smoke and Gas Suffocation)	3	4	3	10
Children Alone in House	0	0	3	3
Clothing Ignited				
Bonfires, Burning Rubbish, etc.	3	0	0	3
Candles and Torches	0	0	1	1
Furnaces, Stoves, and Heaters	3	0	1	4
Smoking in Bed	1	1	0	2
Explosions				
Chemicals	4	0	0	4
Dusts	1	0	0	1
"Empty" Tanks, Welding of	3	0	0	3
Explosives	61	11	0	72
Miscellaneous and Unknown	13	0	0	13
Fire Fighting—Firemen	2	0	0	2
Fire Fighting—Civilians	2	0	0	2
Flammable Liquids and Vapors				
Gasoline and Similar Liquids				
Used for Cleaning Purposes	1	0	0	1
Used to Kindle Fire	0	1	3	4
Miscellaneous	0	0	2	2
Kerosene, Range Oil, and Fuel Oil				
Stoves, Lamps, and Torches	1	0	4	5
Oil Furnaces	1	0	0	1
Indirect Causes (overexertion, exposure, etc.)	1	0	0	1
Mine Fires and Explosions	56	0	0	56
Motor Vehicle Fires (except Tank Trucks)	1	2	0	3
Tank Trucks	1	0	0	1
Trapped in Burning Buildings	12	4	11	27
No Data	1	0	0	1
Total	172	23	28	223

ruptured and sprayed the men with blazing oil. The fire occurred at a plant where copper piping was being bent under heat applied from fuel oil fired torches. Each torch was supplied from a fifteen-gallon tank of fuel oil under some eighty pounds air pressure. Nearly one hundred and fifty sprinkler heads were operated by the blast of flame that occurred when the oil hose became disconnected, and they effectively protected the building and contents. (H-44518.)

Trapped in Burning Buildings.

APRIL 25, 1942, CHATTAROY, W. VA. Three children were trapped and burned to death in a fire which destroyed the houses of eight families, the local post office, and a combination store and restaurant. The fire started from an unknown cause in the dwelling where the children were asleep. The village was without organized fire protection. Volunteers fought the blaze for more than two hours before calling help from the Williamson fire department only three miles distant. Further delay resulted from the necessity of obtaining permission to respond beyond the municipal limits. (H-44521.)

MAY 2, 1942, HOULTON, ME. Two men were burned to death and two others seriously injured in a fire which destroyed a 65-year-old four-story frame

hotel. The fire started during the night in a small shed at the rear of the hotel. Soon after the volunteer fire department arrived the flames reached a gas container which exploded violently, spreading the fire to the Exchange Hotel, which was consumed very rapidly. Within five minutes the entire interior was ablaze. The fire brigade from a near-by military post aided in preventing the fire from spreading to other structures in the business district. The victims were trapped in their rooms on the two upper floors. (H-44513.)

MAY 4, 1942, WEST MILTON, OHIO. A man was burned to death when fire destroyed his small cottage during the night. It is believed that the fire, which may have been caused by a faulty electric stove, had reached such proportions by the time the victim was aroused that he was unable to make his way from the building. (L-6676.)

MAY 5, 1942, WOONSOCKET, R. I. One man was burned to death and three persons were injured when fire of unknown origin swept through a large four-story wooden lodging house. It is reported that there were thirty-two lodgers in the building, which had no fire escapes. Most of the lodgers were asleep when the fire started. The fire originated on an upper floor. (H-44511.)

Loss of Life by Fire, April-June, 1942.

This is a typical rather than a complete record, presented to show the conditions under which loss of life occurs, that they may be known and guarded against. The total loss of life by fire in the United States is estimated at 10,000 annually.

Occupancy	No. Fires	Men	Women	Children	Total
Aircraft	1	1	0	0	1
Apartments, Hotels, Lodgings, Tenements, etc.	10	9	2	5	16
Dwellings—rural	11	3	4	17	24
Dwellings—urban	9	3	4	4	11
Forest and Brush Fires	1	1	0	0	1
Garages and Filling Stations	2	1	0	1	2
Manufacturing Occupancies	7	11	8	0	19
Mercantile Occupancies	2	2	0	0	2
Military Property	2	13	0	0	13
Mining Property	1	56	0	0	56
Motor Vehicles (except Tank Trucks)	1	1	2	0	3
Tank Trucks	1	1	0	0	1
Munitions Mfg.	6	65	3	0	68
Out-of-door Fires	5	5	0	0	5
No Data	1	0	0	1	1
Total	60	172	23	28	223

...and all is well

The illustration shows an A.D.T. supervised watchman transmitting a signal to an A.D.T. Central Station. At prescribed intervals during his tour of duty he sends these signals, and so long as they come in on schedule, the Central Station knows that "all is well."

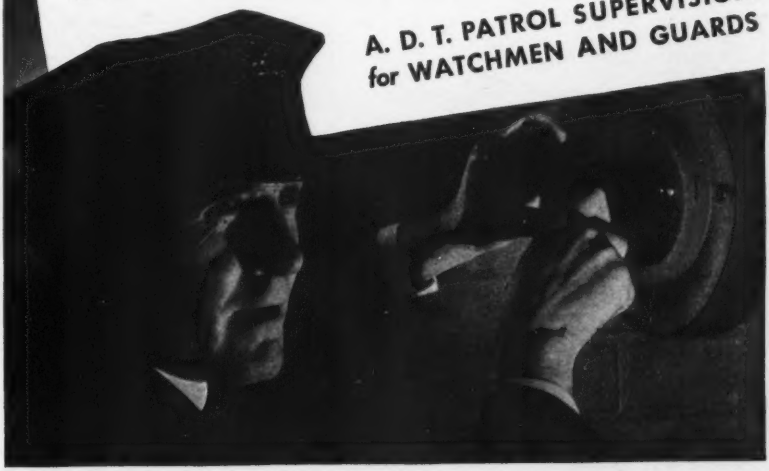
But suppose that all is *not* well. Suppose that for any reason—accident, illness, attack by intruders—the watchman fails to signal. *With A.D.T. Supervision, failure of the watchman to signal on time is an automatic call for help.* The Central Station promptly investigates, dispatching armed and bonded guards when necessary to render emergency assistance, notifies designated officials, and arranges for continuity of the watch patrols if the regular watchman is incapacitated.

In conjunction with Watchman Supervision A.D.T. also provides Manual Fire Alarm Boxes to summon the fire department directly to the scene of any fire outbreak and emergency signaling devices for secretly summoning police assistance.

This comprehensive supervision and backing up of the watchman by an independent, outside organization of trained experts assures maximum effectiveness of guard and watchman forces. It keeps constant watch over the watchman's performance—not the following morning—but from minute to minute while he is making his patrols.

Write for free descriptive booklets.

A. D. T. PATROL SUPERVISION for WATCHMEN AND GUARDS



A. D. T. ELECTRIC PROTECTION SERVICES

Controlled Companies of **AMERICAN DISTRICT TELEGRAPH CO.** *155 Sixth Ave., New York*

CENTRAL STATION OFFICES IN ALL PRINCIPAL CITIES OF THE U.S.

A·D·T

Electric Protection Services

AGAINST FIRE · BURGLARY · HOLDUP

A NATION-WIDE ORGANIZATION

. . . because PYRANOL *cannot* burn

PYRANOL transformers have extra protection against fires from internal arcing, also against external fires because the cooling liquid is noninflammable. That's why the Underwriters' Laboratories approve Pyranol and why the National Electrical Code permits the installation of Pyranol transformers indoors without expensive fireproof vaults as previously required.

Recommend Pyranol Transformers for Safety with Savings

Plant managers and engineers will be glad to use Pyranol transformers not only because they provide extra safety, but also because they can be placed right where they should be placed—close to the load they are to serve. This makes possible short secondary leads—vital copper is saved, voltage regulation is improved, installation time and expense are reduced.

For complete information on Pyranol, and for facts that will show to office-building managers and industrial-plant engineers how they can save money by installing Pyranol transformers, write for Bulletin GEA-2637. *General Electric Co., Schenectady, N. Y.*

GENERAL ELECTRIC

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Supervisory Equipment for Industrial Sprinkler Systems

VIKING supervisory equipment guards against sprinkler system failure. Don't take the chance of having the water supply shut off from YOUR sprinkler system. VIKING can supply you with the necessary supervisory devices to give an electric alarm or signal whenever any essential valve on your sprinkler system is disturbed from its normal wide-open position, or if the pressure gets too low.

THE VIKING CORPORATION

HASTINGS, MICHIGAN

FOR more than a generation this company has furnished cast iron pipe for water supply lines, distribution mains and fire protection mains to cities and towns throughout the United States, as well as for industrial plants, institutions, etc. Most of the largest high pressure fire service systems in this country are constructed of U. S. Cast Iron Bell-and-Spigot Pipe. We furnish pit cast or centrifugally cast pipe in a full range of sizes and various types of joints.

U. S. PIPE & FOUNDRY CO.

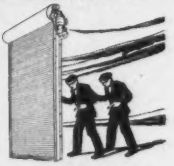
General Offices: Burlington, N. J.

Foundries and Sales Offices throughout the U. S.

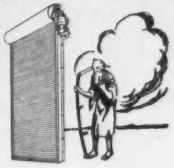
EFFICIENT DOORS THAT

Repel Fire

ALSO BLOCK SABOTEURS



AND RESIST WEAR



Kinnear Rolling Doors give you the protection you need at doorways to safeguard vital war production *plus* the door efficiency you need to help keep production rolling at top speed. Their famous interlocking-slat construction (Kinnear *originated* it) provides strong, durable, *lasting* protection against fire, riot, theft, sabotage, wind, weather and accidental damage. And they aid production by saving space, time and labor—they open upward, smoothly and easily; they coil compactly out of the way right above the doorway; they permit full use of all floor, wall and ceiling space at all times; and their operation is never obstructed by nearby objects. Give your plant—and your production—these proved advantages. Install Kinnear Rolling Doors now. Any size, motor or manual control.

You'll also find valuable extra protection in Kinnear Rolling Fire Doors and Window Shutters. They're approved and labeled by the Underwriter's Laboratories! Write for complete data. The Kinnear Manufacturing Company, 2250-70 Fields Avenue, Columbus, Ohio.

SAVING WAYS IN DOORWAYS

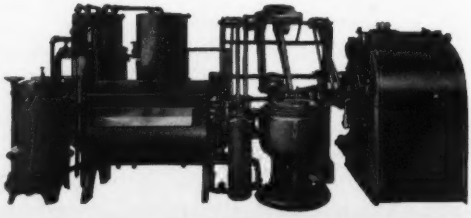
KINNEAR ROLLING DOORS

While we are at all times interested in promoting greater safety in the use of the equipment we sell to the dry cleaning industry we are especially proud of this new development. Here for the first time is a petroleum solvent dry cleaning unit which has been granted listing by the Underwriters' Laboratories, Inc., under their Reexamination Service.

Such listing of course assures fire authorities and insurance rate-making bureaus that 140-F units will be built to specified standards and will be properly inspected.

USES 140° FLASH PETROLEUM SOLVENT

The Hoffman 140F dry cleaning unit employs a new solvent with flash point of approximately 140° F. The unit has many unusual features, including a drying tumbler with temperature automatically controlled throughout the drying cycle.



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EQUIPMENT FOR EVERY DEPARTMENT OF THE DRY CLEANING PLANT

$500,000 Fire Wrecks New Washington Building

A flammable canvas tarpaulin, ignited by sparks from a salamander, roared into a blaze that gutted and buckled the steel skeleton of the new 11-story Statler Hotel, only three blocks from the White House in the heart of the Nation's Capital.

For a few cents per yard, FIRE CHIEF Finished Duck would have prevented this needless loss of money and vital time (the building was to have supplied emergency government office space on completion).

Wherever flammable canvas presents a hazard, indoors or out, from sabotage or carelessness, FIRE CHIEF treated Canvas assures safety. Permanently fire-, water- and weather-resistant, it is approved by both the Underwriters Laboratories and the Associated Factory Mutual Fire Insurance Companies. Meets all Government requirements.

WM. E. HOOPER & SONS CO.

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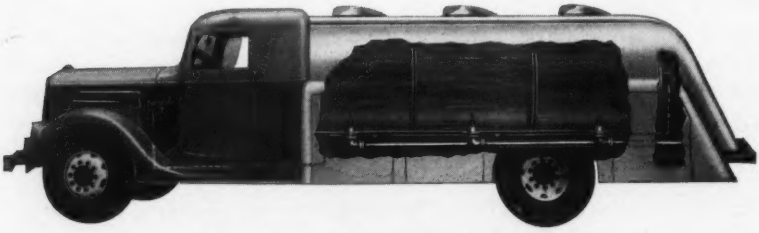
FIRE CHIEF *The Finish That WON'T WASH OUT*

A PAIL OF SAND!

—may be sufficient to extinguish an incendiary bomb, but if a tank truck, whose compartments are unprotected by S. & J. Internal Hydraulic Safety Valves, became involved in an accident in one of your congested districts—it might require all of your apparatus, as well as equipment from neighboring cities, to bring the blaze under control. If you are not fully conversant with the hazards and the Underwriters' Approved safeguards, write for a copy of our free book, "Transporting Inflammable Liquids with Safety."

This is one of four different types of S. & J. Internal Safety Valves, available in sizes from 1½ to 6 inches.



SHAND & JURS CO.

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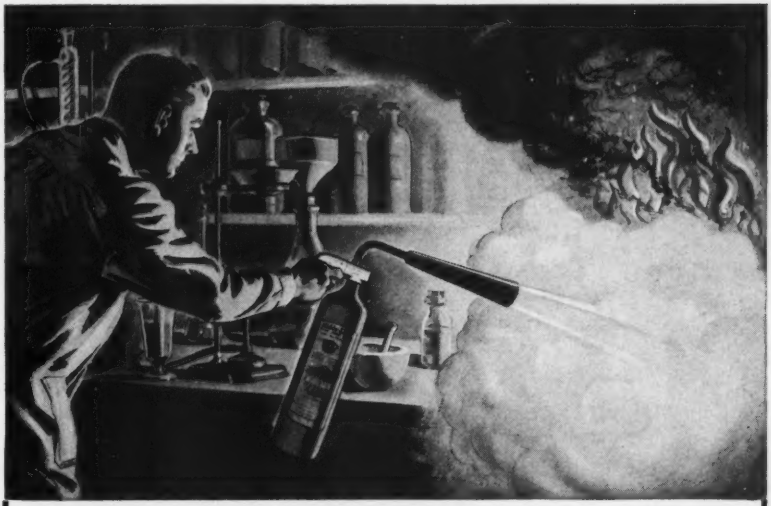

PULL THE TRIGGER *KILL THE FIRE!*

Here it is! . . . the fastest-action, easiest-to-operate fire-killer you ever saw!

There's a pistol grip for one-handed action and for quick maneuverability. There's a trigger-control for fast, easy discharge. Only the Kidde has these sensible, simple features.

You can get Kidde trigger-control extinguishers with 2 or 4 lbs. of carbon dioxide capacity. Use them against flammable liquid or electrical fires. Hang Kidde units in laboratories and garages, near work benches and on your trucks. When fire strikes, Kidde snuffs it out fast in a flurry of carbon dioxide snow-and-gas. Just *aim . . . shoot . . . kill the blaze!*

Think this over: Newly-hired workers may not know how to handle some industrial-type extinguishers in a sudden emergency. *But anyone knows how to pull a trigger!*

K Kidde
SNUFFS OUT FIRE

Walter Kidde & Company
Incorporated
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★ **This is one of a series of advertisements appearing in a list of industrial publications.** ★

Fire-Fighters Appreciate

VALVES
HYDRANTS

AND PIPE LINE ACCESSORIES

M & H products are well known for high quality material and expert workmanship. They have been widely used throughout the country for many years. They include several types of Gate Valves, Check Valves, Flap Valves, Valve Boxes, B & S Fittings, Flanged Fittings, Fire Hydrants and many other cast iron pipe line accessories.

AWWA & UNDERWRITERS APPROVED FIRE HYDRANTS

M & H Fire Hydrants are dry top and revolving head. They are easy to lubricate. Maintenance costs are low due to simplicity of design and rugged construction. They have low friction loss and great efficiency because barrel diameter is not reduced and there are no working parts or obstruction in waterway. Special Traffic model is designed to yield at the ground line under impact. Repair is simple and easy by renewing breakable bolts and breakable coupling on stem.

M&H VALVE
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But WHAT COULD *FIRE* DO TO DEFEAT THESE ACCOMPLISHMENTS?"

America has won the war of production! The world's greatest industrial force has accomplished a Herculean task of adaptation and conversion . . . meeting and surpassing the new, complex requirements of today. And these accomplishments, this ground gained, must be protected against every conceivable threat of disruption . . . protected to the *utmost* against the most destructive, illusive threat of all — FIRE.

Incorporating and improving upon the desirable features of both the wet and dry pipe systems, the Suprotex Sprinkler System offers the ultimate degree of fire protection for conditions of ordinary hazard in plant, office or warehouse. At the first sign of fire, the system automatically fills with water, thereby giving the benefit of instant discharge when the sprinkler heads fuse. Yet, an accidental break in the sprinkler piping or fittings causes no flow of water or water damage, but merely sounds a trouble alarm, calling for proper attention. Repairs are made without shutting off the protection. There is no danger of Suprotex Sprinkler piping freezing because it carries no water while standing guard. Suprotex maintains a supervisory air pressure of only 1½ pounds (instead of the usual 25 to 50 pounds necessary to restrain the water supply); thus, the fire is not fanned by a release of compressed air. Control valves are self-supervised so that they cannot be maliciously turned off without sounding an alarm.

SUPROTEX:
The Guard of Industry at War

"AUTOMATIC" SPRINKLER CORP. OF AMERICA

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INDUSTRY ANSWERS THE CALL!

32,145 FIRMS WITH MORE THAN 17,700,000 EMPLOYEES HAVE INSTALLED THE

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Have YOU Started the Pay-Roll Savings Plan in YOUR Company?

Like a strong, healthy wind, the Pay-Roll Savings Plan is sweeping America! Already more than 32,145 firms, large and small, have adopted the Plan, with a total of over seventeen million employees—and the number is swelling hourly.

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U. S. Defense BONDS ★ STAMPS

NEVER TOO LITTLE OR TOO LATE

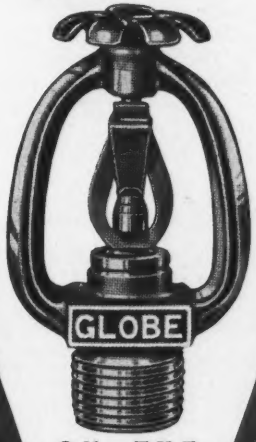
VICTORY AFTER VICTORY

IS PROVING THE FIRE DEFENSE VALUE

"POWER TO WIN"

OF GLOBE EQUIPMENTS

ALWAYS



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APPROVED BY ALL GOVERNMENT AND INSURANCE AUTHORITIES

GLOBE DEVICES CONSERVE METALS, ARE MINIMUM SIZE AND WEIGHT AND GIVE

MAXIMUM PERFORMANCE

USED WHERE RESULTS ARE A MAJOR CONSIDERATION

NEWS OF GLOBE TRIUMPHS POURING IN FROM DEFENSE PLANT FRONTS JUSTIFIES THE CONFIDENCE THAT THEY ARE —

SAFEGUARDING VITAL MAN HOURS AND ELIMINATING DAMAGE AND DISRUPTION CAUSED BY FIRE

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Sales and Engineering Offices in Principal Cities

NEW ROCKWOOD G-40

DOUBLE ACTION
WATERFOG and STRAIGHT STREAM FIRE HOSE NOZZLE

This new Rockwood combination nozzle will enable you to get greater fire extinguishing action out of your present hose lines. It is a far more formidable fire fighting weapon than the old straight stream nozzles now in use in most industrial plants.

The Type G-40 Rockwood WaterFOG Nozzles will not only discharge a straight stream such as your present old style nozzles produce; but in addition, the G-40 Nozzle breaks up water into fog particles. These fog particles, known as WaterFOG, have an amazing extinguishing action on all types of fires—particularly fires in flammable liquids.

It's a simple matter to operate the G-40 Nozzle. From *shut-off* position a slight movement forward of the control handle produces a WaterFOG discharge. Another forward movement of the handle produces a straight stream discharge. WaterFOG is produced in larger volume and projected a greater distance than has been possible heretofore, because of the *internal impingement* method used in the G-40 Nozzle—an exclusive Rockwood development.

Increase the efficiency of your existing fire hose lines by replacing your old style nozzles with the new Type G-40 Rockwood WaterFOG Nozzles. Also specify the G-40 Nozzle for any new fire hose lines you may be installing. They are available in 4 sizes to fit ¾", 1", 1½" and 2½" hose lines. Write for prices and descriptive literature.

Upper photo shows WaterFOG Pattern discharged by 1½" Type G-40 Rockwood WaterFOG Nozzle. Lower photo shows straight stream discharged by same nozzle. Water pressure was 100 lbs. p.s.i. at the nozzle when each of the above photos was made.

This phantom photo shows the simple control of the Type G-40 Rockwood WaterFOG Nozzle. (Left) — control handle in shut-off position, (center) — position for WaterFOG discharge, (right) — position for straight stream discharge.

ROCKWOOD SPRINKLER COMPANY
Sprinkler Systems & Fire Protection Engineering
WORCESTER, MASSACHUSETTS
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GAMEWELL

Fire Alarm Watch, and Plant Supervisory Systems

for

Government, Industrial, Railroad and Institutional Properties

Fire interrupts the continuity of business and is reflected in the loss of intangible values far greater than the replaceable physical values destroyed. Delays in the discovery and announcement of Fire and Crime . . . the principal causes of large losses and consequent interruptions of operations . . . are minimized by Gamewell signaling systems.

INDUSTRIAL PROPERTIES

such as the following rely upon Gamewell systems for emergency signaling.

BELL TELEPHONE SYSTEM	250 properties
GENERAL ELECTRIC COMPANY	13 plants
WESTINGHOUSE ELECTRIC & MFG. CO.	5 "
INTERNATIONAL HARVESTER CO.	8 "
FORD MOTOR CAR CO.	9 "
DuPONT DE NEMOURS & CO.	32 "
PULLMAN CAR & FOUNDRY CO.	7 "

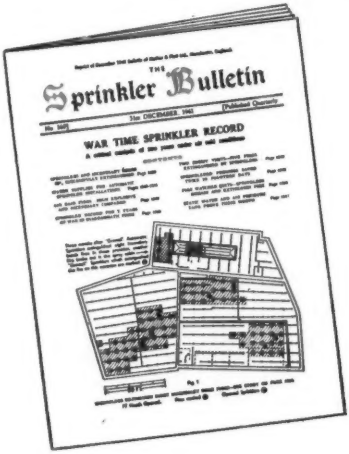
There is a reason why. Write for complete information.

THE GAMEWELL COMPANY

NEWTON UPPER FALLS

MASSACHUSETTS

England's Report



on Sprinkler Fire Protection!

Here is an amazing report from the scene of history's worst fire perils. It is an authentic record of the performance of automatic sprinkler fire protection in actual air raids. And it shows that no premises fully protected by automatic sprinklers with a dependable water supply have been destroyed by incendiary bomb fires in England!

Reprinted for the first time in this country, this Bulletin throws new light on protective measures against impending incendiary bombings on our own continent . . . 250 incendiary bombing incidents in sprinkler equipped buildings throughout industrial Britain form the basis of this Report.

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